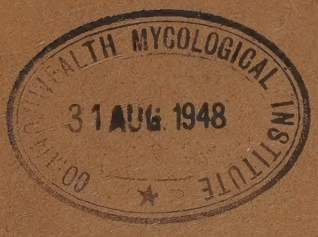
THE TOBACCO RESEARCH BOARD
PUBLICATION No. 8. 1944

TRELAWNEY TOBACCO RESEARCH STATION

ANNUAL REPORT

for 1944



PRINTED BY THE ART PRINTING WORKS, LIMITED
SALISBURY 43876/8/44 S. RHODESIA

TRELAWNEY TOBACCO RESEARCH STATION

ANNUAL REPORT

for 1944

PRINTED BY THE ART PRINTING WORKS, LIMITED
SALISBURY 43876/8/44 S. RHODESIA

CONTENTS

I. General Report.

II. Agronomy.

III. Breeding and Selection.

IV. Combined Varietal and Manurial Trials.

V. Root Knot Nematode.

Report of the Tobacco Research Board for the Year ended December 31st, 1944

THE BOARD

The present personnel of the Board is as follows:—

Nominees of the Honourable the Minister of Agriculture and Lands:

A. D. HUSBAND, F.I.C. (Chairman).

D. D. BROWN.

Representatives of the Rhodesia Tobacco Association:

A. M. HUTCHINSON.

C. F. JOHNSON.

Representatives of the Salisbury Chamber of Commerce (Tobacco Section):

C. A. BARRON.

I. REID ROWLAND, C.B.E.

STAFF

Senior Field Husbandry Officer	H. F. ELLIS, M.SC.
Officer i/c Laboratories (Plant Breeder)	A. A. MOFFETT, PH.D., B.SC.
Plant Pathologist .. .. *(On Active Service.)*	I. P. NORVAL, M.SC.
Entomologist (temporary)	R. W. JACK, F.E.S.
Farm Foreman	F. SCAMELL.
Accounts	Messrs. SPEIGHT, GOLDBY AND WEBBER

GENERAL REPORT

Introduction.

During the previous two seasons, reduction in staff due to calling-up of officers for full-time military service had led to a considerable curtailment of the experimental work. The position was, however, partially relieved during the past season by the appointment of a Farm Foreman, and with the additional assistance a considerable expansion of the programme of experimental work was rendered possible.

A number of experiments were designed to cover, as far as possible, all phases of tobacco culture, the treatments included for trial being based on the results and experience of a number of years. Experiments on very similar lines to those described in this Report had been carried out on the Station in the past, but with one important difference, *i.e.*, all the fertilizer had previously been applied before planting.

The almost universal adoption of the method of fractional application of fertilizer for tobacco largely vitiated the results of these former experiments, rendering a repetition necessary. At the same time an examination of past results led to two important conclusions—

(1) that to obtain conclusive results, the experiments must be continued for an indefinite number of seasons. Three consecutive years is not sufficient to allow for seasonal variation;

(2) that, despite the conclusions reached in 1940 (Tobacco Research Board Publication No. 5), that there was no interaction of variety with fertilizer, later information indicated that it was very probable that some such interaction did occur. Chemical analysis of leaf samples of three varieties, taken at different stages of growth, showed a differential uptake of the main fertilizer nutrients (unpublished data), and it seemed probable that these chemical differences would show up in yield or quality in a sufficiently comprehensive experiment.

In order to cover seasonal variations in any particular experiment, a range of treatments likely to cover all practical possibilities was drawn up and each experiment was planned to continue in the same form for a number of years. Other experiments were designed to test varieties in combination with the main manurial ingredients.

As shown in the reports of the investigations, complex experiments of this nature have already given indications of important results. Doubtless, as the work progresses, information will become available which will suggest other profitable lines of investigation.

It was not possible during the past season to put the full programme planned into practice. Experiments designed to test different combinations of topping, spacing and priming had to be omitted, but will be included in next year's programme.

TABLE I—DETAILS OF TOBACCO SOLD—1943-44 CROP.

	Bales	Weight in lbs.	Gross Value	Average Gross Price Realised per lb.	Weighing and Auction Fees	Commission	Levy	Railage	Sundry Charges	Total Charges	Net Value	Average Net Price Realised per lb.
			£ s. d.		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	
Tobacco Producers' Floor, Ltd. ..	60	9,422	890 19 5	22·70	3 0 0	22 5 6	3 16 0	2 2 8	——	31 4 2	859 15 3	21·90
Tobacco Auctions, Ltd.	65	8,637	945 16 10	26·28	3 5 0	23 12 11	3 7 0	2 5 1	0 1 9	32 11 9	913 5 1	25·38
Tobacco Producers' Floor, Ltd. ..	51	5,662	467 2 8	19·80	2 11 0	11 13 9	2 3 3	1 19 1	——	18 7 1	448 15 7	19·02
Tobacco Producers' Floor, Ltd. ..	1	98	1 16 9	4·50	0 1 0	0 1 0	0 0 6	——	——	0 2 6	1 14 3	4·19
	177	23,819	2,305 15 8	23·23	8 17 0	57 13 2	9 6 9	6 6 10	0 1 9	82 5 6	2,223 10 2	22·40

A number of rotations were commenced on third-year land. A similar series will be laid down each year on land which has carried two crops of tobacco, so that in due course one complete series of rotations will come under tobacco each year.

The total area under experiments was 50 acres, of which approximately 40 acres were planted to tobacco, the other 10 acres being taken up with rotations and nematode experiments.

Details of tobacco sold are given in Table I.

Weather Conditions.

The past season was again one of heavy rainfall, a total of 43·46 inches being recorded at the Laboratory. Unlike the 1942–43 season, there were considerable periods of sunshine, and the growth of the tobacco as a whole was good. Nevertheless, compared with the appearance in the field, the yields of cured leaf were disappointing, due largely to the heavy rains of February.

In view of the importance of the distribution, as well as the total, rainfall, detailed figures for the season are given in Table II. It should be mentioned that as the nematode experiments were carried out some distance from the main Station, these rainfall figures do not apply accurately to this series of investigations.

Insect Pests.

The damage caused by insect pests was on a reduced scale compared with the previous season. Crickets again caused considerable loss on the light sands, but on the heavier soil types damage by insects was slight.

Disease.

Damage due to bacterial diseases was slight, although some loss was caused by angular spot on a second-year rotated land. Fungal diseases caused considerable losses. Alternaria was prevalent on two lands, more especially on the upper leaves, towards the end of the season. The lands attacked were the rotation experiment mentioned above, and a second-year land on which compost trials were being carried out. In both cases a very considerable loss in both yield and quality were caused by this disease.

The first three reapings throughout the crop were only lightly attacked by frogeye, but later pickings, taken during the heavy rains in February, suffered considerably from barn-spot.

The incidence of mosaic over the whole crop was low, being computed at about ½%.

Presentation of Results.

The following is a brief outline of the methods used for evaluating and tabulating the results of the experiments.

All yields are graded weights, only saleable leaf being taken into account.

TABLE II

RAINFALL FOR SEASON 1943–1944

Date	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
1 ..	—	—	0·08	0·02	—	0·04	—
2 ..	—	—	—	—	0·08	—	—
3 ..	—	0·02	—	1·50	0·22	—	—
4 ..	—	0·23	0·26	0·64	0·51	1·32	—
5 ..	—	0·57	—	1·01	0·80	0·03	0·02
6 ..	—	0·23	—	0·03	1·32	0·52	0·01
7 ..	—	0·35	0·78	0·27	0·24	—	—
8 ..	—	—	0·09	0·32	0·02	—	—
9 ..	—	—	0·10	0·33	—	—	—
10 ..	—	—	0·58	0·17	0·31	0·23	—
11 ..	—	0·11	0·02	0·36	0·09	1·11	—
12 ..	—	—	—	—	0·57	—	—
13 ..	—	—	0·05	—	0·53	—	—
14 ..	—	—	—	0·11	0·03	—	—
15 ..	—	0·01	0·15	0·09	—	—	—
16 ..	0·02	0·05	0·07	0·60	—	0·55	—
17 ..	—	0·04	1·76	0·39	0·14	—	—
18 ..	—	0·54	0·35	0·31	0·01	—	—
19 ..	—	—	0·18	—	2·26	—	—
20 ..	—	—	1·81	—	0·43	—	—
21 ..	—	—	0·42	—	0·06	—	0·02
22 ..	—	—	0·78	—	0·05	—	—
23 ..	—	0·12	1·39	—	3·57	—	—
23 ..	—	0·48	—	—	0·09	—	—
25 ..	—	—	—	1·20	0·72	—	—
26 ..	—	0·57	—	—	0·22	—	—
27 ..	—	0·06	0·02	0·39	0·78	—	—
28 ..	—	0·29	0·02	—	1·67	—	0·09
29 ..	—	—	2·24	0·03	1·49	0·34	—
30 ..	—	0·17	—	0·01	—	—	—
31 ..	—	—	0·18	—	—	—	—
TOTAL	0·02	3·84	11·33	7·78	16·21	4·14	0·14

SEASONAL TOTAL: 43·46 inches.

The average prices were arrived at in a similar manner to last season. Samples were taken from each grade in each experiment. These samples were then classified by leaf experts into standard commercial grades, and a basic price assigned to each grade. The basic prices, which range from a minimum of 1½*d.* per pound to a maximum of 18*d.* per pound, are constant for any

particular grade from year to year. The results given for average price and value per acre are strictly comparable with those of last season. The results worked out on this basis gave cash returns of approximately ¼ of the actual market value.

The results are tabulated in two ways, one column giving the actual yields, prices or values, while, to facilitate scrutiny, a second column expresses the results as a percentage of the mean, *i.e.*, the average yield, price or value is taken for the whole experiment, and the result of individual treatments given as a percentage of this average.

Where statistical analysis has shown results to be significant, significant differences are given below each Table.

Acknowledgments.

We are indebted to the Imperial Tobacco Company and to Messrs. J. Reid Rowland & Company, whose representatives classified the tobacco; also to the Rhodesia Tobacco Marketing Board for arranging facilities for classification on the Auction Floors.

II

AGRONOMY

With a great increase in the number of treatment types tested compared with the previous season, the agronomic investigations were divided into two sections, as follows:—

(*a*) Experiments to test methods of application of compost and fertilizer, to determine the best sources of nitrogen and to test a number of rotations.

(*b*) Experiments to test the effects of different levels of the main fertilizer ingredients in varying combinations with each other, and with compost and varieties.

As it was expedient, from the point of view of tobacco culture in general, to obtain information as to the effect of varying fertilizer levels on different varieties, a number of varieties were included in the latter experiments, the tests being carried out in collaboration with Dr. Moffett. The results of these experiments, from the point of view of both variety and fertilizer, are discussed in Part IV of the Report. The remaining trials discussed below therefore come exclusively under section (*a*) above.

DESCRIPTION AND RESULTS OF EXPERIMENTS

1. Method of Application of Compost.

The object of the experiment was to ascertain, over a period of years, if the yield and quality of the crop were affected by the manner in which compost at different levels was applied. Nine treatments were tested as follows, the initial planting in all cases being made in hills:—

(1) 2½ tons per acre in hills before planting.

(2) 5 tons per acre in hills before planting.

(3) 2½ tons per acre, broadcast before planting.

(4) 5 tons per acre, broadcast before planting.

(5) 2½ tons per acre, round the plants 3 weeks after planting.

(6) 5 tons per acre, round the plants 3 weeks after planting.

(7) 2½ tons per acre, ground compost in hills before planting.

(8) 5 tons per acre, ground compost in hills before planting.

(9) No compost.

The soil was a reddish, sandy loam opened in August, 1942, and carrying its second successive crop of tobacco. Other experimental details were as follows:—

Planted 5th December, 1943.

The variety used was Bonanza.

Fertilizer was applied as follows:—

(1) 100 lbs. per acre of Standard (6–6–8) on 3rd December, 1943.

(2) 100 lbs. per acre of Standard (6–6–8) on 5th January, 1944.

Treatments (5) and (6) were composted on 28th December, 1943.

A randomized block layout was used with six replications, each plot being $\frac{1}{40}$ acre in extent.

No analysis of the compost was made, but since the materials used, and the method of manufacture had not altered, it was assumed that the following analysis, based on the average of several similar composts, would fairly represent its composition:—

Moisture	39·5 %
Organic Matter	14·7 %
Sand	40·3 %
Soluble Ash	5·3 %
Organic Carbon	8·3 %
Nitrogen	0·59%
C/N Ratio	13·2 %
P_2O_5	0·35%
K_2O	0·22%
C_aO	1·77%

The results are summarized in Table I as follows:—

TABLE I

Treatment	Yield *lbs.*	% of Mean	Value	% of Mean	Price *pence*	% of Mean
1	765	98·24	£25 1 0	94·15	7·85	95·74
2	781	100·31	27 3 0	102·05	8·36	101·97
3	755	96·96	25 8 0	95·47	8·08	98·55
4	766	98·37	26 8 0	99·23	8·27	100·87
5	786	100·94	26 9 0	99·41	8·04	98·06
6	806	103·52	28 1 0	105·43	8·36	101·97
7	797	102·35	27 13 0	103·93	8·32	101·48
8	764	98·12	26 0 0	97·72	8·19	99·89
9	788	101·19	27 6 0	102·61	8·32	101·47

Z test not significant.

	Yield	Value	Price
Mean	779 lbs.	£26 12 0	8·20*d.*
Standard Error	4·50%	4·63%	1·76%

No significant differences in yield, value or price.

Compost had no affect on yield, value or price per pound, no matter in whatever way it was applied.

In previous Reports (Tobacco Research Board Publications 4 and 5) it was shown that applications of compost at the rate of 3½–4 tons per acre gave significant increases in yield and value. In 1939–40 the land was a good type of sandy loam soil, carrying its fourth successive crop of tobacco, and

the response to both 4 and 8 tons of compost per acre was highly significant. In 1940–41, on a light grey sand, carrying its second successive crop of tobacco, there was a response to $3\frac{1}{2}$ tons compost per acre, but no significant increase in yield when the level was raised from $3\frac{1}{2}$ to 7 tons per acre. In both cases the soils were in a relatively low state of fertility, due in the former to the exhausting effect of three previous crops, and in the latter to low initial fertility. In the present instance where the soil was of a better type and in a relatively high state of fertility, the response to compost was negligible.

It seems probable that on a relatively good type of second-year land an application of compost is not likely to bring about any marked increase in yield. This result was confirmed by a more accurate experiment discussed in Part IV of this Report.

2. **Sources of Nitrogen.**

The object of the experiment was to ascertain the effect of nitrogen from different sources on the yield and quality of tobacco. Similar experiments had previously been carried out by Mr. Thorpe, although in this case all the fertilizer was applied before planting. However, in view of the general adoption of the system of fractional application of fertilizer, it appeared desirable to repeat the experiment. It must be regarded, nevertheless, as a long-term project, as variations in climatic conditions very probably affect the results. The failure to obtain differential results cannot, therefore, be regarded as final.

Nine treatments were tested, as follows:—

(1) $\frac{1}{3}$ nitrogen from Nitrate of Soda, $\frac{2}{3}$ from Ammonium Sulphate.

(2) $\frac{1}{3}$ nitrogen from Nitrate of Soda, $\frac{1}{3}$ from Ammonium Sulphate, and $\frac{1}{3}$ from Blood Meal.

(3) $\frac{1}{3}$ nitrogen from Nitrate of Soda, $\frac{1}{3}$ from Ammonium Sulphate, and $\frac{1}{3}$ from Ground Nut Cake.

(4) $\frac{1}{4}$ from Nitrate of Soda, $\frac{1}{2}$ from Ammonium Sulphate, and $\frac{1}{4}$ from Blood Meal.

(5) $\frac{1}{4}$ from Nitrate of Soda, $\frac{1}{2}$ from Ammonium Sulphate, and $\frac{1}{4}$ from Ground Nut Cake.

(6) $\frac{2}{3}$ from Ammonium Sulphate, $\frac{1}{3}$ from Blood Meal.

(7) $\frac{2}{3}$ from Ammonium Sulphate, $\frac{1}{3}$ from Ground Nut Cake.

(8) $\frac{1}{3}$ from Ammonium Sulphate, $\frac{2}{3}$ from Blood Meal.

(9) $\frac{1}{3}$ from Ammonium Sulphate, $\frac{2}{3}$ from Ground Nut Cake.

The soil was a pinkish-grey sand, opened in August, 1942, and carrying its second successive crop of tobacco.

The source and total amount of phosphate and potash were kept constant, only the source of nitrogen being varied.

All plots received fertilizer at the following levels:—

P_2O_5 .. 72 lbs. N .. 24 lbs. K_2O .. 32 lbs.

Fertilizer was, therefore, applied at the rate equivalent to 400 lbs. per acre of 18–6–8 (Tobacco No. 4).

Other experimental details were as follows:—

Planted 8th December, 1943.

The variety used was Bonanza.

Fertilizer was applied as follows:

(1) 150 lbs. per acre on 6th December, 1943.

(2) 250 lbs. per acre on 10th January, 1944.

A randomized block layout was used with six replications, each plot being $\frac{1}{40}$ acre.

The results are summarized in Table II as follows:—

TABLE II

Treatment	Yield *lbs.*	% of Mean	Value	% of Mean	Price *pence*	% of Mean
1	623	100·62	£18 0 0	96·66	7·00	96·88
2	639	103·19	19 12 0	105·25	7·38	102·14
3	587	94·80	17 5 0	92·63	7·06	97·71
4	664	107·23	20 7 0	109·28	7·33	101·45
5	616	99·48	18 12 0	99·88	7·23	100·06
6	611	98·67	18 14 0	100·42	7·38	102·14
7	570	92·05	17 0 0	91·29	7·17	99·23
8	603	97·38	18 1 0	96·92	7·19	99·50
9	660	106·58	20 1 0	107·67	7·29	100·89

Z test not significant.

	Yield	Value	Price
Mean	619 lbs.	£18 12 0	7·22*d.*
Standard Error	4·80%	4·91%	2·17%

None of the treatments had any effect on yield, value or price per pound, a result similar to that obtained by Mr. Thorpe. It seems probable that in a year of abnormal rainfall, the total amount of nitrogen applied is of greater importance than the source from which it is derived. Provided a proportion of the nitrogen is present in a readily available form, it is possible that with fractional applications it may not be necessary to include so large a proportion of the more slowly available fertilizers, such as animal and plant proteins, thus reducing the cost of the mixture.

3. **Method of Application of Fertilizer.**

The objects of the experiment were threefold—

(*a*) To test two methods of incorporating the fertilizer in the soil.

(*b*) To test the number of applications of fertilizer required.

(*c*) To test the proportion of the total to be given with each application of fertilizer.

The experiment was of the split-plot design, with four replications, each sub-plot being $\frac{1}{40}$ acre.

The treatments were as follows:—

Main Plots.

(*A*) Fertilizer incorporated round plants in hills.

(*B*) Fertilizer placed in small holes adjacent to plants, which were planted on ridges.

The following sub-treatments were then imposed on each of these main treatments:—

(1) $\frac{1}{2}$ fertilizer before planting, $\frac{1}{2}$ about 4 weeks after planting.

(2) $\frac{2}{3}$ fertilizer before planting, $\frac{1}{3}$ about 4 weeks after planting.

(3) $\frac{1}{3}$ fertilizer before planting, $\frac{2}{3}$ about 4 weeks after planting.

(4) $\frac{1}{3}$ before planting, $\frac{1}{3}$ 3 weeks after planting, $\frac{1}{3}$ 5 weeks after planting.

(5) $\frac{1}{2}$ before planting, $\frac{1}{4}$ 3 weeks after planting, $\frac{1}{4}$ 5 weeks after planting.

(6) $\frac{1}{5}$ before planting, $\frac{2}{5}$ 3 weeks after planting, $\frac{2}{5}$ 5 weeks after planting.

(7) $\frac{2}{5}$ before planting, $\frac{2}{5}$ 3 weeks after planting, $\frac{1}{5}$ 5 weeks after planting.

(8) $\frac{1}{4}$ before planting, $\frac{1}{2}$ 3 weeks after planting, $\frac{1}{4}$ 5 weeks after planting.

The soil was a reddish, sandy loam, opened in August, 1942, and carrying its second successive crop of tobacco. Other experimental details were as follows:—

Planted 5th December, 1943.

The variety used was Bonanza.

All treatments received fertilizer at 400 lbs. per acre to give the following amount of plant nutrients:

37 lbs. per acre .. .. P_2O_5

18 lbs. per acre .. .. N.

24 lbs. per acre .. .. K_2O

All plots received the first application of fertilizer on 2nd December before planting.

Treatments 4–8 were re-fertilized on 28th December, 1943, and 10th January, 1944.

Treatments 1–3 were re-fertilized on 5th January, 1944.

Field Observations.

In all cases where the fertilizer was thoroughly incorporated in the soil, growth was extremely rapid, and about eight weeks after planting it appeared that the plots so treated would out-yield those in which the fertilizer was applied in holes. The latter, however, continued to grow after the former started to mature, and eventually no difference was discernible. There was not at any period any visible difference in growth due to the sub-plot treatments.

The results are summarized in Table III as follows:—

TABLE III

Treatment	Yield *lbs.*	% of Mean	Value	% of Mean	Price *pence*	% of Mean
1	705	90·70	£23 11 0	91·76	7·97	100·69
2	748	96·24	25 1 0	97·72	8·05	101·71
3	711	91·48	23 9 0	91·37	7·92	100·06
4	812	104·47	26 7 0	102·67	7·79	98·42
5	771	99·20	25 7 0	98·73	7·84	99·05
6	846	108·84	27 8 0	106·80	7·76	98·04
7	794	102·15	26 17 0	104·66	8·12	102·59
8	831	106·92	27 6 0	106·29	7·87	99·44

Z test significant.

	Yield	Value	Price
Mean	777 lbs.	£25 13 0	7·93*d.*
Standard Error	4·01%	4·11%	1·28%
Significant Differences ..	89 lbs. *or*	£3 0 0 *or*	0·29*d.*
	11·45%	11·73%	3·66%

Yield.

Treatment 6 better than 1, 2 or 3.

Treatment 8 better than 1 or 3.

Treatment 4 better than 1 or 3.

Value.

Treatment 6 better than 1 or 3.

Treatment 8 better than 1 or 3.

Treatment 7 better than 1 or 3.

Price per lb.

Treatment 7 better than 6 or 4.

Discussion.

Climatic conditions, particularly the distribution and intensity of rainfall, have so marked an effect on the availability of fertilizer that no real conclusions can be drawn until the experiment has been repeated for a number of years.

Although there was a difference of only 30 lbs. or £1 per acre in favour of incorporating the fertilizer thoroughly in the soil, the extremely rapid and continuous growth that it caused gives grounds for the belief that under different seasonal conditions, *i.e.*, late drought, the response in yield and value would be considerably greater.

In the sub-plot treatments, generally better results were given with three applications of fertilizer than with two. The highest yield was obtained where

a comparatively low application was given before planting with subsequent dressings of twice the initial amount. With good growing conditions prevailing until mid-February, soil nitrification was rapid and the initial fertilizer dressings had no differential effect, as was evidenced by field observation.

It is possible, therefore, that the late application of comparatively large dressings of fertilizer had the effect of tiding the plants over the heavy rains experienced during the latter portion of the growing season.

4. **Commercial Fertilizer Test.**

At the request of African Explosives & Chemical Industries, Ltd., a test was made of a fertilizer having a higher ratio of nitrogen to the other ingredients than has hitherto been used. This was compared with Tobacco No. 4 (Bloodmeal), which was the standard fertilizer in use before the war.

Four treatments were tested, as follows:—

(1) 400 lbs. per acre of 18–6–8 (Tobacco No. 4 (Bloodmeal)).

(2) 300 lbs. per acre of 14–8–10 (new type mixture).

(3) 300 lbs. per acre of 18–6–8.

(4) 250 lbs. per acre of 14–8–10.

The soil was a reddish, sandy loam, opened in August, 1943, and carrying its first crop.

Other experimental details were as follows:—

Planted 8th December, 1943.

Refilled 18th December, 1943.

The variety used was Bonanza.

Fertilizer was applied as follows:

(1) ½ of fertilizer applied before planting.

(2) ½ applied on 22nd January, 1944.

Growth was very good, but the tobacco produced was "flashy," and lacking in feel and body.

The results of yield, value per acre and average price per pound are summarized in Table IV as follows:—

TABLE IV

Treatment	Yield *lbs.*	% of Mean	Value	% of Mean	Price *pence*	% of Mean
1	731	96·89	£28 11 0	96·78	9·37	99·84
2	818	108·41	32 0 0	108·47	9·39	100·05
3	738	97·81	28 16 0	97·63	9·37	99·84
4	731	96·89	28 13 0	97·12	9·41	100·27

Z test not significant.

	Yield	Value	Price
Mean	754 lbs.	£29 10 0	9·39*d.*
Standard Error	4·80%	4·94%	1·48%

As there are no differences between treatments, it appears, on one year's test, that the new fertilizer is as satisfactory as the old Tobacco No. 4 Bloodmeal.

5. Rotation Trials.

This experiment was a continuation of the one reported last year (Tobacco Research Board Publication 7), designed to test, on as large a scale as possible, the relative merits of four rotations all employing crops in general use. To test the duration of the rotation effects, all plots were located in the same position as in the previous year.

The rotations were as follows:—

(1) Tobacco, tobacco, maize, sunn hemp (stubble ploughed in), munga (ploughed in).

(2) Tobacco, tobacco, 3 years Rhodes Grass.

(3) Tobacco, tobacco, 3 years fallow.

(4) Tobacco, tobacco, 3 years dhal (Cajanus indicus).

Each plot occupied approximately one acre and was replicated three times. The soil was a reddish, sandy loam, underlain by a red, sandy clay subsoil.

Other experimental details were as follows:—

Planted 19th November, 1943.

The variety used was Bonanza.

Fertilizer was applied as follows:

(1) 150 lbs. per acre of 10–6–8 before planting.

(2) 100 lbs. per acre of 6–6–8 on 18th December, 1943.

Although growth at first was rather slow, the tobacco eventually filled out and gave promise of a high yield. Unfortunately, however, it was subsequently severely attacked by alternaria and angular spot, which greatly reduced both the yield and quality. Apart from the damage caused by "spot," the leaf produced was of a good bodied, oily type.

The results of this experiment are summarized in Table V as follows:—

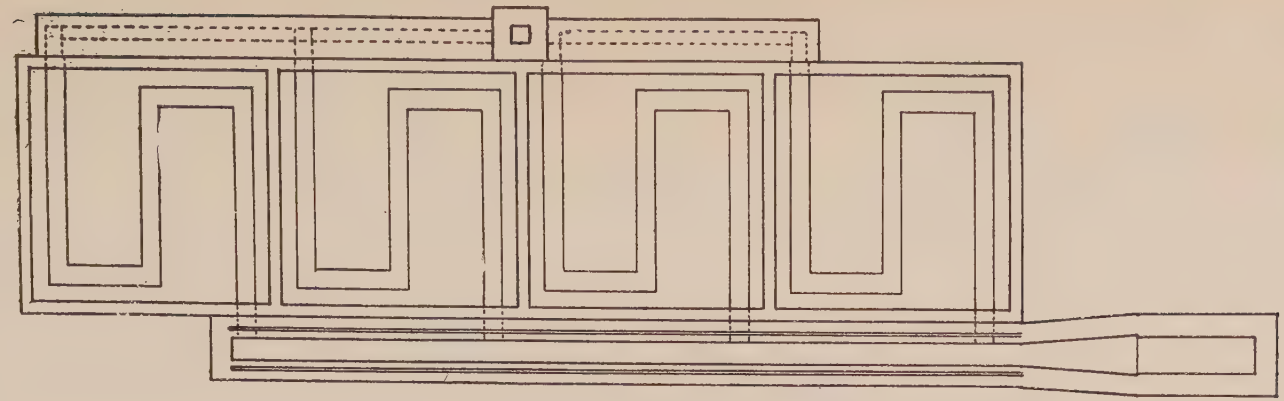
TABLE V

Treatment	Yield *lbs.*	% of Mean	Value	% of Mean	Price *pence*	% of Mean
1	496	92·67	£15 6 0	92·52	7·42	99·93
2	615	114·90	18 16 0	113·68	7·34	98·86
3	536	100·14	16 15 0	101·28	7·50	101·01
4	494	92·29	15 6 0	92·52	7·44	100·20

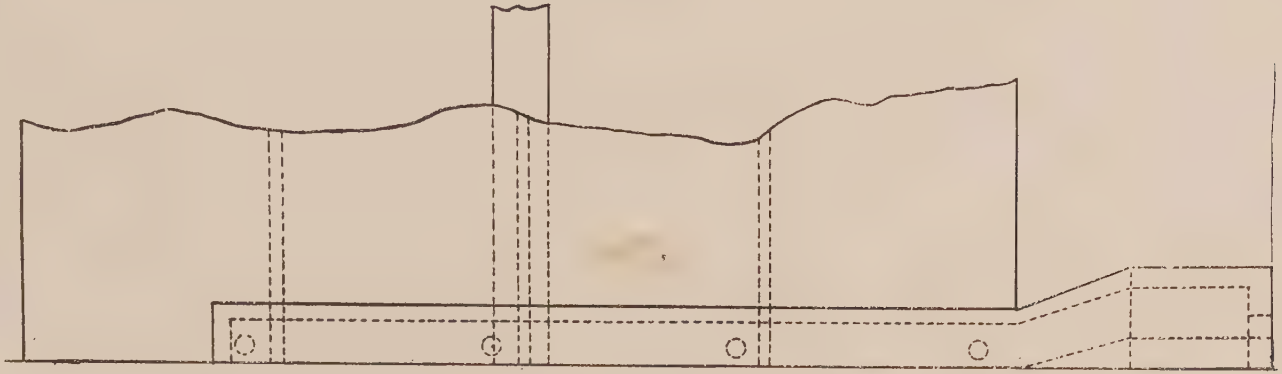
Z test not significant.

	Yield	Value	Price
Mean	535 lbs.	£16 11 0	7·42*d.*
Standard Error	6·14%	6·53%	1·58%

DIAGRAM OF SIMMONS HEATING UNIT



PLAN



ELEVATION

Although none of these differences is significant, the yields and values are in the same order as in the previous year. The results of the two seasons have, therefore, been combined and show a high degree of significance.

The results of the two seasons are summarized in Table VI as follows: —

TABLE VI

Treatment	Yield *lbs.*	% of Mean	Value	% of Mean	Price *pence*	% of Mean
1	573	94·95	£17 10 0	95·69	7·34	100·89
2	684	113·34	20 13 0	112·92	7·24	99·52
3	622	103·06	18 18 0	103·35	7·30	100·34
4	535	88·65	16 2 0	88·04	7·22	99·24

Z test significant.

	Yield	Value	Price
Mean	602 lbs.	£18 6 0	7·27*d.*
Standard Error	3·5%	3·8%	0·66%
Significant Differences ..	64 lbs. *or* 10·6%	£2 2 0 *or* 11·48%	—

Yield.

Treatment 2 better than 1 and 4 and almost better than 3.
Treatment 3 better than 4.

Value.

Treatment 2 better than 1 and 4.
Treatment 3 better than 4.

The highest yields and values over the two seasons were given by the two treatments in which the grass cover was either permanent or nearly so, that is, following either Rhodes Grass or fallow. A permanent grass crop has given better results than a permanent legume, and the effect of the considerable quantity of organic wastes ploughed under has extended into the second season.

On the whole, three years Rhodes Grass has given the best results of the four treatments, and can safely be recommended as a suitable rotation for most types of tobacco soil.

6. **Tests on Coal-Burning Furnace.**

Further tests were carried out on the coal-burning furnace designed by Mr. B. G. Gundry, of the Irrigation Divisions. Seven curings in all were made, with an average consumption of coal of 2,500 lbs. per curing throughout the season.

Remarks.

This furnace was again found to be satisfactory in operation, even in the hands of inexperienced native stokers. On the basis of the experience of the past two seasons, it could well be used on properties where the supply of timber has been reduced to such an extent that curing a crop is no longer possible.

7. **Tobacco Barns with Single Furnace and Combined Flue.**

Experiments were carried out with a new type of heating unit designed by Mr. A. Simmons, of Salisbury.

Details of these experiments and a diagram of the heating unit are contained in the following report, which was compiled by Mr. Simmons.

Tests were also made on other systems of heating and ventilation, the results of which have not so far proved sufficiently promising to merit any detailed comment.

Tobacco Barns with Single Furnace and Combined Flue

Experiments were carried out during the 1943 and 1944 seasons with a furnace having a combined flue serving three or more barns, the design being covered by Patent No. 47 of 1942, granted to Mr. A. Simmons.

The main idea behind this design was to reduce the consumption of fuel by utilizing one furnace for a number of barns, these being served by a single large flue with separate branches to each barn, with sliding damper doors controlling the flow of heat.

In the first trials carried out with this furnace the standard practice of having a separate chimney built for each barn was tried.

It was found, however, to be difficult in practice to distribute evenly the heat to the three barns, as although a large amount of heat was built up in the furnace and main flue, the draught in the chimneys was weak and there was a strong tendency when all the damper doors were opened for a down-draught to develop in one of the chimneys and thus completely upset the even distribution of heat to the respective barns.

The plan of having separate chimneys of equal height not being successful, it was decided to build a single chimney 40 feet high serving three barns with all the flues directly connected thereto.

When testing the furnace with the single chimney it was noted there was no tendency to down-draught in any flue and the draught was considerably stronger with a corresponding increase of heat in the furnace and main flue.

The amount of heat delivered to the three standard $16' \times 16'$ barns, however, was not as great as had been expected. It was found that with a very small damper door opening the temperature in No. 1 barn would rise to 128 degrees Fahrenheit, and No. 2 and 3 barns with larger openings to 120 and 90 degrees only, with a large fire being maintained in the furnace.

It was noted that with a slightly larger opening of the damper door to No. 1 barn, the temperature here would readily rise to 200 degrees Fahrenheit in a few minutes. This result was obtained with a flame about 20 feet long, reaching to the entrance to the barn flue, but even with these conditions the temperature in barns 2 and 3, distant, 16 and 32 feet further along the main flue, would not rise beyond the 120 degrees and 90 degrees already noted.

In considering the causes of this disappointing thermal result, it will first be pertinent to describe the furnace and main flue employed.

The furnace was built with a grate size of $2'\ 6'' \times 6'\ 0''$, the inner walls were built in firebrick and the outer wall completed in common brick, the finished thickness being 18 inches.

The main manifold flue connecting to the furnace has a $4\frac{1}{2}$-inch firebrick inner wall, followed by a 3-inch air space, and is completed with an outer 9-inch wall of common brick.

The roof of the main flue is formed of firebrick slabs 6 inches thick, covered in with a 6-inch layer of tamped clay.

With this degree of insulation a wood fire producing a flame up to 20 feet long and a firebox temperature of between 1,200 and 1,500 degrees Fahrenheit, it was established that the necessary barn temperature of 160 degrees could not be reached in more than one barn at a time.

It appears clear that in order to obtain the desired results with this design it would be necessary to use a still larger furnace, provide more insulating material in the manifold flue, and build a taller chimney to improve the draught. This would result in an equipment too costly to justify adoption by the tobacco planter.

The conclusions to be drawn from the tests described are—

(1) that the heat required to be supplied to a standard $16' \times 16'$ tobacco barn in order to obtain a temperature of 160 degrees Fahrenheit is considerably more intense than had been generally thought;

(2) that the most efficient way to supply this heat is by building a furnace for each separate barn, placed as close to the barn as possible.

III

BREEDING AND SELECTION

The variety trials of the previous two seasons had led to the conclusion "that large experiments on a semi-commercial scale yield little information which cannot equally well be obtained from small plots by a system of sampling and classification." All experiments during the season under review were, therefore, laid out in small plots, permitting the testing and comparison of 44 varieties and strains.

The breeding experiments were conducted in five sections, concerning respectively—

A. Comparisons between varieties and maintenance of yield and quality.

B. Testing of newly-imported varieties.

C. Production of new types by hybridization and selection.

D. Resistance to mosaic.

E. Resistance to nematode.

Experiments were also carried out in conjunction with Mr. Ellis to test the reaction of some of the more widely grown varieties to different manurial treatments. The results of these combined experiments will be discussed in a separate section of this Report.

The yields throughout the experiments were fairly good on the whole. Heavy rains during the season, especially in February, caused a general reduction in quality, which tended to level out differences between varieties. Early reapings were free from spot, but pickings taken in February were heavily attacked by barn spot, and it is the prevalence of this disease which did much to mask varietal differences in quality.

DESCRIPTION AND RESULTS OF EXPERIMENTS

A. This experiment consisted of a test of seven varieties, including those most widely grown commercially. The varieties were as follows:—

(1) Jamaica Wrapper.

(2) Willow Leaf.

(3) White Stem Orinoco.

(4) Yellow Mammoth.

(5) Virginia Bright.

(6) Bonanza.

(7) Gold Dollar.

The objects of this experiment were threefold—

(1) As a check on any possible deterioration within the varieties.

(2) To make rigid selections as a basis for bulking seed in the following season for distribution to commercial growers.

(3) To obtain information as to the varietal response to climatic conditions over a number of seasons.

A reverted land which had carried, previously, two years' tobacco, fallow, maize, three years' weed fallow, was used for the experiment. The land had been ploughed during the previous March, and most of the grass and other organic matter had broken down by the time of planting. Other experimental details were as follows:—

Planted 26th November. Resulting stand good, one refilling only being necessary.

Fertilizer was applied as follows:

150 lbs. per acre No. 4 bloodmeal (18–6–8), applied round marker and covered by a hill before planting.

100 lbs. per acre No. 4 on 23rd December.

25 lbs. per acre Nitrate of Soda on 8th January, 1944.

Experimental Design.—A Latin Square, giving seven replications of each variety.

The results of yield, average price and value per acre are summarized in Table I.

TABLE I

No.	Variety	Yield per Acre		Price per Pound		Cash Value per Acre			
		lbs.	% of Mean	*pence*	% of Mean	£	*s.*	*d.*	% of Mean
A 1	Jamaica Wrapper ..	858	107·6	8·22	99·9	29	12	0	108·1
A 2	Willow Leaf ..	773	97·0	8·14	98·9	26	6	0	95·9
A 3	White Stem Orinoco	804	100·9	8·37	101·7	28	2	0	102·5
A 4	Yellow Mammoth ..	762	95·6	8·30	100·8	26	8	0	96·5
A 5	Virginia Bright ..	804	100·9	8·14	98·9	27	6	0	99·8
A 6	Bonanza	834	104·6	8·36	101·6	29	0	0	106·1
A 7	Gold Dollar ..	740	92·8	8·08	98·2	24	18	0	91·0

Z test not significant.

	Yield	Price	Value
Mean of all varieties	797 lbs.	8·23*d.*	£27 8 0
S.E.	3·90%	1·22%	4·04%

The *Z* test was not significant, but as it approached significance on the basis of yield and value, the *T* test was applied. The differences given below as significant are, therefore, subject to verification by further experimentation, although in the case of Gold Dollar there can be little doubt from results of previous years that the low yield is a real varietal characteristic.

	Yield	Price	Value
Differences shown to be significant by *T* test	90 lbs. *or* 11·3% of Mean	None	£3 4 0 *or* 11·6% of Mean

Jamaica Wrapper gave a better yield than Yellow Mammoth or Gold Dollar, while Bonanza gave a better yield than Gold Dollar.

Both Jamaica Wrapper and Bonanza gave a better cash return than Gold Dollar.

The low yield of Gold Dollar is further confirmed by the results of other experiments in the present season. This variety is evidently not sufficiently vigorous for the light soils, whilst it may prove to be suitable for heavy or contact soils where there is a tendency for the growth to become too rank.

No very striking differences were observed in the quality of the leaf, which fell almost entirely into bright grades. The leaf from Virginia Bright was of a harsh texture, and once again it was noticed that the better leaf in White Stem Orinoco came from the bottom of the plant, whereas in the case of Bonanza the upper leaves produced the best quality.

B. This trial included ten varieties from Canada, a local commercial strain of Jamaica Wrapper and a Station strain of Bonanza, the latter as a standard for comparison. The trial was carried out on a second-year land, of one of the heavier soil types of the Station, *i.e.*, a pink sandy loam, with a fair proportion of clay. The experimental details were as follows:—

Planted 29th November.

Fertilizer applied as follows:

100 lbs. per acre 14–8–10 mixture before planting (around marker and covered by hill).

100 lbs. per acre 14–8–10 mixture on 30th December.

Experimental Design.—Randomized blocks with six replications.

The varieties tested and a summary of the results of yield, price per pound and value are given in Table II.

TABLE II

No.	Variety	Yield per Acre		Price per Pound		Cash Value per Acre			
		lbs.	% of Mean	*pence*	% of Mean	£	*s.*	*d.*	% of Mean
B 1	Bonanza Can. 68 ..	692	93·0	8·45	106·4	24	3	0	98·8
B 2	Bonanza Can. 47 ..	706	94·9	7·97	100·4	23	6	0	95·3
B 3	Bonanza Station Strain	841	113·0	8·09	101·9	28	2	0	115·2
B 4	White Mammoth Can. 61	816	109·7	7·55	95·1	25	9	0	104·2
B 5	Proctor's Special Can. 71	768	103·2	7·97	100·4	25	7	0	103·9
B 6	Gold Dollar Can. 82	747	100·4	8·10	102·0	25	0	0	102·5
B 7	Gold Dollar Can. 69	733	98·5	7·79	98·1	23	11	0	96·5
B 8	Yellow Mammoth Can. 58	803	107·9	7·86	99·0	26	0	0	106·5
B 9	Duquesne Can. 72 ..	610	82·0	8·24	103·8	20	15	0	85·0
*B*10	Jamaica Wrapper Local	800	107·5	7·67	96·6	25	5	0	103·4
*B*11	Harrison's Special Can. 66	694	93·3	7·72	97·2	22	7	0	91·6
*B*12	White Stem Orinoco Can.	726	97·6	7·86	99·0	23	13	0	97·0

Z test significant at 0·05% and 0·01% points.

	Yield	Price	Value
Mean of all varieties	744 lbs.	7·94*d.*	£24 8 0
Standard Error ..	4·24%	1·50%	4·29%
Significant Difference 5%.	90 lbs. *or* 12·1% of Mean	0·40*d. or* 5·00% of Mean	£2 19 0 *or* 12·1% of Mean
Significant Difference 1%.	119 lbs. *or* 16·0% of Mean	0·53*d. or* 6·62% of Mean	£3 19 0 *or* 16·2% of Mean

Significant differences may be summarized as follows:—

Yield at 5% *point.*

B 3	better than	1, 2, 6, 7, 9, 11, 12.
4	,, ,,	1, 2, 9, 11, 12.
8 and 10 ..	,, ,,	1, 2, 9, 11.
2, 5, 6, 7 and 12	,, ,,	9.

Yield at 1% *point.*

B 3	better than	1, 2, 9, 11.
4	,, ,,	1, 9, 11.
5, 6, 7, 8 and 10	,, ,,	9.

Price at 5% *point.*

B 1	better than	2, 4, 5, 7, 8, 10, 11, 12.
9	,, ,,	4, 7, 10, 11.
6 and 3 ..	,, ,,	4, 10.
2	,, ,,	4.

Price at 1% *point.*

B 1	better than	4, 7, 8, 10, 11, 12.
9	,, ,,	4, 10.
3 and 6 ..	,, ,,	4.

Value at 5% *point.*

B 3	better than	1, 2, 6, 7, 9, 11, 12.
8	,, ,,	11, 12.
1, 4, 5, 6, 8 & 10	,, ,,	9.

Value at 1% *point.*

B 3	better than	1, 2, 7, 9, 11, 12.
4, 5, 6, 8 and 10	,, ,,	9.

The fact that the *Z* test is significant at the 1% point shows that very marked differences occur within this group of varieties. Apart from those shown above to be significant, in many other cases the differences between varieties in yield, price and value closely approaches the level of significance, and may possibly be shown to be due to real varietal characteristics by further experimentation.

From a commercial point of view, the Station strain of Bonanza has given the best results, the cash return from this variety being significantly better than almost any of the other varieties, except *B* 8. The commercial strain of Jamaica Wrapper, although giving a comparatively good yield, produced leaf of poor quality, reflected by the low price.

Amongst the imported varieties, the high quality of *B* 1 (Bonanza 68) is of particular interest. Although the yield of this strain of Bonanza was comparatively low, it may prove to be useful on the heavier soils where a type which is not too vigorous seems to be required. *B* 9 (Duquesne) has been grown on this Station in previous seasons, and has always given bright leaf of high quality. This variety is, however, weakly in growth, even in the seed-beds, and consists of a number of types. Attempts to select a uniform strain combined with high quality have so far been unsuccessful. Some of the other varieties, particularly *B* 6 and *B* 8, show promise, but further testing and selection of all these varieties is necessary before coming to any conclusions.

C. This experiment consisted of a trial of 12 selections made in progeny of four inter-varietal crosses and 13 strains previously selected within varieties.

The hybrids and strains were as follows:—

Gold Dollar × Jamaica Wrapper	3 selections from F_2 generation.
Bonanza × Willow Leaf ..	3 selections from F_2 generation.
Bonanza × Jamaica Wrapper ..	3 selections from F_2 generation.
Willow Leaf × Jamaica Wrapper	3 selections from F_2 generation.
Bonanza	6 strains selected within the variety.
Jamaica Wrapper	4 strains selected within the variety.
Gold Dollar	1 strain selected within the variety.
Willow Leaf	1 strain selected within the variety.
White Stem Orinoco ..	1 strain selected within the variety.

The main objects of this experiment were to provide comparable material for selection in the progeny from the inter-varietal hybrids, and to examine the strains within the varieties with a view to their suitability to varying soil types.

It was not expected that at this stage the varietal hybrids would give uniform types, but in order to get a clear picture of the varietal characteristics, it was necessary to eliminate, as far as possible, variation due to soil differences. Owing to the extremely variable nature of tobacco lands, and the marked response of the plant to local soil conditions, it is practically impossible to distinguish hereditary variations from fluctuations due to environment unless a replicated layout is used. Furthermore, a direct comparison of these hybrids with proved selections of varieties should give a good measure of their potentialities for selection.

With regard to the varietal strains, previous results had led to the conclusion that little further improvement could be effected by straightforward selection. These strains had not, however, been grown before on reverted land and it was hoped that reverted land in combination with one of the better soils on the Station might bring to light differences not observed hitherto, which would be of use in assessing their value for varying soil types. It is becoming evident, however, that only very limited progress can be made with the production of strains or varieties suitable for different localities, more especially those with contact or heavy soils, owing to the restricted range of soils on the Station on which trials can be made.

The trial was made on a land which had grown the following crops: 2 years tobacco, fallow, maize, 3 years Rhodes grass, the last mentioned being ploughed under during the previous March. The soil was a reddish, sandy loam, underlain by quartz gravel, but in spite of its colour, it could not be considered to be as heavy as a contact soil.

Other experimental details were as follows:—

Planted 25th November. Fertilizer applied as follows:

150 lbs. per acre 14–6–8 mixture before planting.

100 lbs. per acre 14–6–8 mixture on 23rd December.

25 lbs. per acre Nitrate of Soda on 8th January.

Experimental Design.—A Symmetrical Incomplete Block Arrangement, with six replications. Blocks consisted of five plots of $\frac{1}{40}$ acre area each.

The whole land was remarkably free from insect pests, and with favourable conditions a very good stand was obtained with the first planting. The strains and selections, together with a summary of the results, are given in Table III.

TABLE III

No.	Variety	Yield per Acre		Price per Pound		Cash Value per Acre			
		lbs.	% of Mean	*pence*	% of Mean	£	*s.*	*d.*	% of Mean
C 1	Gold Dollar × Jamaica Wrapper, Selection 1	752	104·3	8·04	100·9	25	4	0	105·0
C 2	Gold Dollar × Jamaica Wrapper, Selection 2	645	89·4	7·42	93·1	20	0	0	83·3
C 3	Gold Dollar × Jamaica Wrapper, Selection 3	643	89·2	8·17	102·5	21	18	0	91·2
C 4	Bonanza × Willow Leaf Selection 1	728	101·0	7·88	98·9	24	0	0	100·0
C 5	Bonanza × Willow Leaf Selection 2	760	105·4	7·92	99·4	25	0	0	104·5
C 6	Bonanza × Willow Leaf Selection 3	740	102·6	8·07	101·3	24	18	0	104·0
C 7	Bonanza × Jamaica Wrapper, Selection 1	787	109·1	7·94	99·6	26	0	0	108·4
C 8	Bonanza × Jamaica Wrapper, Selection 2	686	95·1	7·90	99·1	22	16	0	95·3
C 9	Bonanza × Jamaica Wrapper, Selection 3	725	100·5	8·26	103·6	24	18	0	104·0
*C*10	Willow Leaf × Jamaica Wrapper, Selection 1	736	102·1	8·14	102·1	24	18	0	104·0
*C*11	Willow Leaf × Jamaica Wrapper, Selection 2	708	98·2	7·78	97·6	22	18	0	95·7
*C*12	Willow Leaf × Jamaica Wrapper, Selection 3	749	103·7	8·09	101·5	25	6	0	105·6
*C*13	Bonanza .. 3/40	692	95·8	8·07	101·2	23	6	0	97·3
*C*14	Bonanza .. 4/40	755	104·7	8·22	103·1	25	18	0	108·1
*C*15	Bonanza .. 6/40	694	96·2	7·97	100·0	23	0	0	95·9
*C*16	Bonanza .. 8/40	711	98·6	7·94	99·6	23	16	0	99·3
*C*17	Bonanza .. 10/40	707	98·0	8·18	102·6	24	2	0	100·4
*C*18	Bonanza .. 7/40	760	105·4	8·15	102·3	25	16	0	107·8
*C*19	Jamaica Wrap. 13/40	736	102·1	7·90	99·1	24	4	0	101·0
*C*20	Jamaica Wrap. 14/40	804	111·5	7·92	99·4	26	10	0	110·6
*C*21	Jamaica Wrap. 17/40	736	102·1	8·10	101·6	24	18	0	104·0
*C*22	Jamaica Wrap. 18/40	704	97·6	8·01	100·5	23	10	0	98·1
*C*23	Gold Dollar .. 19/40	650	90·1	7·87	98·7	21	6	0	88·8
*C*24	Willow Leaf .. 22/40	691	95·8	7·63	95·7	22	2	0	92·0
*C*25	White Stem Orinoco 23/40	729	101·1	7·57	95·0	22	16	0	95·3

Z test significant at 5% point for yield, price and value.

	Yield	Price	Value
Mean of all varieties	721 lbs.	7·97*d.*	£24 0 0
Standard Error	4·90%	2·04%	5·50%
Significant Difference	99 lbs. *or* 13·7%	0·46*d.* *or* 5·72%	£3 14 0 *or* 15·43%

Significant differences at the 5% point are summarized below.

Yield.

C 20	better than	2, 3, 8, 13, 15, 22, 23, 24.
7	„ „	2, 3, 8, 23.
1, 5, 12, 14, 18	„ „	23, 24.

Price.

C 9	better than	2, 11, 24, 25.
3, 10, 12, 14, 17, 18, 21	„ „	2, 24, 25.

Value.

C 20	better than	2, 3, 8, 23, 24, 25.
7, 14, 18	„ „	2, 3, 23, 24.
1, 5, 12	„ „	2, 23.
4, 6, 9, 10, 16, 17, 19, 21	„ „	2.

In an experiment such as this, involving a fairly large number of varieties, it is not usually possible to reduce the experimental error to a level which will show all real varietal differences to be significant. Therefore, while differences shown to be significant are important, it does not follow that all the other varieties are equal and that fluctuations in yield, etc., are entirely due to soil variation. Varieties showing yield or quality above the average must be re-tested by subsequent experiments, possibly over a number of years. This applies particularly to the varietal hybrids which must still be expected to show considerable segregation for yield, etc. Comments on the behaviour of the strains during the present season must, therefore, be tentative and subject to confirmation.

The hybrids have, on the whole, competed favourably with the varietal strains, only four out of twelve giving cash returns below the average for the whole experiment. Two particularly low yields, in the Gold Dollar × Jamaica Wrapper cross, are of interest. The previous season when the F_2 generation was grown, it was noted that although Gold Dollar was a very weakly variety, the hybrid was more vigorous than crosses between two relatively vigorous types. This cross is now evidently segregating, and splitting into two types, one having the low vigour of Gold Dollar, and the other being more like Jamaica Wrapper.

Two selections from Bonanza × Jamaica Wrapper show promise, Selection No. 1 (*C* 7) because of its high yield, and No. 3 (*C* 9) because of its high quality. When examining cured leaf from individual single plant selections, it was noted that the quality from *C* 9 was very much better than any of the other strains.

The two hybrids combining Willow Leaf with Bonanza and Jamaica Wrapper both show some promise, especially from the point of view of yield.

No very marked variations occurred in the strains of Bonanza, except that Nos. *C* 14 and *C* 18 gave a good combination of yield and price compared with other strains. Amongst the strains of Jamaica Wrapper, *C* 20 gave a significantly higher yield than *C* 22, indicating the possibility of splitting this variety into two types on the basis of vigour.

Gold Dollar (*C* 23) again showed its lack of vigour in a low yield. It was noted, however, that the leaf from well grown-out plants of this variety selected for seed was of high quality, only being out-classed by *C* 9. In both this trial and the *A* mentioned above, Willow Leaf did not show up well, whereas in previous seasons it has given consistently good yields and quality. Apparently, either the climatic conditions or the particular soil type (rather heavier than usual) used this season were unfavourable for Willow Leaf.

White Stem Orinoco (*C* 25), although giving a good average yield, was of poor quality. This strain of White Stem does not appear to be as good as the Greenville strain grown in Experiment *A*.

Some 400 single plant selections were made in the above strains on the basis of field characteristics. Leaf from each selection was reaped and cured, and subsequently examined for quality, degree of sponging and freedom from spot, etc. A number of plants were outstandingly good, and it is hoped that some at least of their characteristics will prove to be hereditary when grown in the coming season.

D. **Mosaic Resistance.**—Breeding for mosaic resistance was continued, using the derived resistance from both *Nicotiana glutinosa* and Ambalema.

With the *glutinosa* type of resistance, while some plants only showed the local necrotic spotting, in a number of cases the virus passed down the midrib into the main stem, causing severe distortion or even death of the plant. Both types occurred in the one family, and it remains to be seen whether this result is an environmental effect or due to segregation of genes.

E. **Nematode Resistance.**—This line of work has been continued, but has been complicated by what appears to be the occurrence of parthenogenesis in crosses made during the winter. Many of these crosses will have to be repeated reciprocally under more favourable conditions.

IV

COMBINED VARIETAL AND MANURIAL TRIALS

The importance of varietal differences in the production of high yields and good quality in tobacco has been shown by straightforward comparisons between varieties, but only limited trials have been carried through to determine whether there is any differential response of varieties to varying fertilizer treatments. It was decided, therefore, when planning experiments to test varying levels of the main fertilizer ingredients, and of compost to include a small number of the more widely-grown varieties in the tests. As seasonal conditions probably have an important bearing on the results, the experiments were planned to run for a number of years so that results over several seasons could be collected and analysed finally. Therefore, whilst some conclusions may be drawn from outstanding treatment effects, results given below must be regarded as an interim report subject to modification when further information becomes available.

Two experiments were laid down, as follows:—

(1) **Experiment M**—to test three varieties in combination with three levels each of Phosphorus, Potassium and Nitrogen.

(2) **Experiment S**—combining three varieties with three levels each of Compost and Nitrogen.

Experiment M.

The following were the varieties and levels of fertilizer ingredients tested:—

Varieties	P_2O_5 per acre	K_2O per acre	Nitrogen per acre
V_1 Jamaica Wrapper ..	P_1 16 lbs.	K_1 32 lbs.	N_1 18 lbs.
V_2 Bonanza	P_2 40 lbs.	K_2 48 lbs.	N_2 27 lbs.
V_3 White Stem Orinoco ..	P_3 64 lbs.	K_3 64 lbs.	N_3 36 lbs.

Nitrogen was supplied as $\frac{1}{3}$ Nitrate of Soda, $\frac{1}{3}$ Ammonium Sulphate and $\frac{1}{3}$ Bloodmeal.

P_2O_5 was supplied as 18% Superphosphates.

K_2O was supplied as Muriate of Potash.

The treatments were tested in all combinations giving $(3 \times 3 \times 3 \times 3)$ or 81 different treatment types. A split plot arrangement was selected for the layout, since a design of this type should give accurate information as to any possible interaction between treatments. By interaction, is meant the results of the combination of two or more treatments which may be dependent on each other for their effects.

The layout consisted of four blocks, each containing three large main plots to accommodate the three varieties. Each main plot was sub-divided into nine sub-plots to take all combinations of the three levels of P_2O_5 and K_2O. Each sub-plot was then sub-divided again into three sub-sub-plots to take the three levels of nitrogen. All treatments were randomized within their respective groups of plots.

The experiment consisted, therefore, of twelve main plots, 108 sub-plots and 324 sub-sub-plots, giving four replications of each variety, 36 replications of each level of phosphate and potash and 81 replications of each level of nitrogen.

Compared with an experiment in which all treatments are replicated an equal number of times, a split plot arrangement of this type results in loss of information on the whole plot treatments, but with a compensating gain on the sub-plot treatments and their interaction with the whole plot treatments. As comparisons between the varieties used could be made in straightforward variety trials, and as it was concerning any possible interactions between variety and fertilizer that information was sought, this loss of precision in the direct comparison was of little importance. Furthermore, by placing the varieties in the main plots, the practical difficulties of planting the experiment were considerably facilitated.

A new land, which had been stumped and ploughed during the previous wet season, was used for three blocks of the experiment. The soil was a very light, white sand, somewhat uneven owing to the presence of termite mounds, which could not be completely avoided when demarcating the plots. The fourth block had to be placed on a second-year land, a pink, sandy loam of a considerably heavier type.

Other details were as follows:—

Planted 25th November, 1943.

Refilled 29th November and 8th and 18th December, 1943.

Fertilizer: ½ before planting, ½ on 28th and 29th December, 1943.

Insect pests, more especially crickets, caused considerable damage in the early stages, resulting in uneven growth. Early reapings were free from spot, but those taken during February were heavily attacked by barn-spot.

Mosaic infection was about ½%.

The results are summarized in Tables I, II and III, as follows:—

TABLE I—RESULTS OF MAIN TREATMENTS

Treatment	Yield per Acre *lbs.*	% of Mean	Price per Pound *pence*	% of Mean	Cash Value per Acre	% of Mean
Jamaica Wrapper ..	800	108·5	7·97	97·4	£26 11 0	105·7
Bonanza	715	96·9	8·27	101·1	24 12 0	98·1
White Stem Orinoco ..	698	94·6	8·29	101·3	24 3 0	96·2
16 lbs. per acre P_2O_5 ..	714	96·8	8·22	100·5	24 8 0	97·3
40 lbs. per acre P_2O_5 ..	735	99·6	8·17	99·9	25 1 0	99·7
64 lbs. per acre P_2O_5 ..	764	103·6	8·14	99·5	25 17 0	103·0
32 lbs. per acre K_2O ..	749	101·5	8·13	99·4	25 6 0	100·8
48 lbs. per acre K_2O ..	756	102·5	8·22	100·5	25 18 0	103·2
64 lbs. per acre K_2O ..	708	96·0	8·18	100·0	24 2 0	96·0
18 lbs. per acre N. ..	673	91·2	8·12	99·3	22 16 0	90·8
27 lbs. per acre N. ..	736	99·8	8·19	100·2	25 1 0	99·9
36 lbs. per acre N. ..	804	108·0	8·21	100·5	27 9 0	109·3

	Yield	Price	Value
Mean, all treatments ..	738 lbs.	8·17*d.*	£25 2 0
Standard Error, Variety ..	2·65%	1·21%	2·47%
Standard Error, P_2O_5 & K_2O	1·82%	0·65%	1·95%
Standard Error, N.	1·16%	0·39%	1·33%
Significant Differences, Variety	67·7 lbs. *or* 9·18%	none	none
Significant Differences, P_2O_5	37·6 lbs. *or* 5·10%	none	none
Significant Differences, K_2O	37·6 lbs. *or* 5·10%	none	£1 8 0 *or* 5·50%
Significant Differences, N. ..	24·0 lbs. *or* 3·25%	none	£0 19 0 *or* 3·74%

Summary of Significant Differences.

Yield.

Jamaica Wrapper.. better than Bonanza or White Stem Orinoco.
64 lbs. P_2O_5 .. ,, ,, 16 lbs. P_2O_5.
32 and 48 lbs. K_2O ,, ,, 64 lbs. K_2O.
27 lbs. Nitrogen .. ,, ,, 18 lbs. Nitrogen.
36 lbs. Nitrogen .. ,, ,, 27 lbs. Nitrogen.

Value.

48 lbs. K_2O .. ,, ,, 64 lbs. K_2O.
27 lbs. Nitrogen .. ,, ,, 18 lbs. Nitrogen.
36 lbs. Nitrogen .. ,, ,, 27 lbs. Nitrogen.
32 lbs. per acre K_2O almost better than 64 lbs. per acre.

Two-Factor Interactions.

One two-factor interaction, namely, that between nitrogen and phosphorus, proved to be significant on the basis of yield.

Table II gives the results of a combination of different levels of these two elements on the yield.

TABLE II

	N_1		N_2		N_3	
	Yield per acre *lbs.*	% of Mean	Yield per acre *lbs.*	% of Mean	Yield per acre *lbs.*	% of Mean
P_1	671	90·9	721	97·7	750	101·6
P_2	652	88·3	724	98·1	828	112·2
P_3	695	94·2	762	103·3	833	112·9

Standard Error: 2·01%.
Significant Difference: 42 lbs. per acre or 5·69%.

Three-Factor Interactions.

Three-factor interaction—that between variety, nitrogen and potash—reached the level of significance on the basis of average price. Table III gives the prices from this triple interaction.

TABLE III

		Jamaica Wrapper			Bonanza			White Stem Orinoco		
		N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
K_1	Price	7·82	7·84	7·98	8·35	8·05	8·16	8·41	8·26	8·31
	% of Mean	95·6	95·8	97·5	102·1	98·4	99·7	102·8	101·0	101·6
K_2	Price	8·02	8·07	8·11	8·34	8·38	8·46	7·91	8·43	8·21
	% of Mean	98·0	98·6	99·1	101·9	102·4	103·4	96·7	103·1	100·4
K_3	Price	8·03	7·90	7·94	8·12	8·36	8·24	8·15	8·43	8·49
	% of Mean	98·2	96·6	97·1	99·3	102·2	100·7	99·6	103·1	103·8

Standard Error: 0·14%.
Significant Difference: 0·27*d.* or 3·3% of mean.

DISCUSSION OF RESULTS

Varieties.

Jamaica Wrapper gave a significantly higher yield than either Bonanza or White Stem Orinoco, indicating that from the point of view of vigour this variety is more suited to the very light sands. The average price of both Bonanza and White Stem Orinoco was higher than Jamaica Wrapper, but as the difference did not reach the level of significance, it must be regarded for the moment as being due to chance. The close returns on yield and price of Bonanza and White Stem Orinoco were surprising, as it was expected that White Stem would prove to be the more vigorous of the two and therefore give better results on a light soil. Its somewhat disappointing yield may, however, be due to seasonal conditions.

The significant triple interaction between variety, nitrogen and potash is of interest, and if supported by future results may prove to be of considerable importance. It is frequently difficult to arrive at the true interpretation of a triple interaction, but from a study of Table III the following would appear to be the explanation. With the lowest level (32 lbs. per acre) of potash, there is no response to increased levels of nitrogen in Jamaica Wrapper or White Stem Orinoco, but Bonanza shows a significantly higher price with the first level of nitrogen than with the second. With the second and third levels of potash (48 and 64 lbs. respectively), there is no response to increased nitrogen in Jamaica Wrapper or Bonanza, but in both cases the second and third levels of nitrogen have given a significantly higher average in White Stem.

It would appear, therefore, that a combination of high potash and high nitrogen has a beneficial effect on the quality of White Stem Orinoco but not on that of the other two varieties.

Phosphate and Nitrogen.

These two factors are considered together, as they appear to be so mutually inter-dependent it is difficult to consider the full effects of each separately. Taken independently the results are as follows. Raising the level of P_2O_5 from 16 to 64 lbs. per acre has given a significant increase in yield, but not in price or value. Each increase in the level of nitrogen has given a significant increase in both yield and value, but not in price. The interaction between phosphorus and nitrogen was, however, significant and the combined effects of these two fertilizer ingredients would seem to be of the greatest importance. The interaction, the results of which are summarized in Table II, may be explained as follows:—

With the lowest level of phosphate, there is a significant increase of yield when the level of nitrogen is raised from 18 to 27 lbs., but 36 lbs. nitrogen does not give a further significant increase.

With the second level of phosphate, there is a significant increase in yield from the first to the second levels of nitrogen, while there is a very marked increase from the second to the third level.

With the third level of phosphate, the action of nitrogen is similar to the second level.

Reading the table in the other direction, it will be noticed that the third level of phosphate only shows its fullest effect in the presence of high nitrogen. Thus, with the first level of nitrogen there is no significant increase in yield between P_1 and P_3 (P_2 in this case appears to be an anomalous result). With the second level of nitrogen, there is an almost significant increase from P_1 to P_3, while with the third level of nitrogen there is a highly significant increase with both P_2 and P_3 over P_1.

It would appear from these results, therefore, that to obtain the maximum benefit from high dressings of nitrogen, it must be balanced by an adequate amount of phosphate. This was confirmed by observations in the field, where it was noticed that while the colour of plants having high nitrogen and low phosphate was good, growth was very slow compared with plants having similar nitrogen and high phosphate. What constitutes an adequate amount of phosphate to balance the nitrogen apparently depends largely upon the seasonal conditions. In the season under consideration, a dressing of 40 lbs. P_2O_5 per acre was apparently sufficient to balance 36 lbs. of nitrogen per acre, as no further increase in yield occurred when this level of nitrogen was combined with 64 lbs. P_2O_5. The season was, however, one of heavy rainfall, so it must be assumed that a considerable portion of the nitrogen applied was lost by leaching, whereas phosphate is not subject to loss in this manner. Under conditions of more moderate rainfall, when a greater proportion of the nitrogen would be available to the plant, a higher level of phosphate would probably be needed to balance the nitrogen, and a further increase in yield occurs when the highest levels of the two ingredients were combined.

The results are in close agreement with those obtained by Thorpe in the 1936–37 season (Report of The Tobacco Research Board, *R.A.J.*, 1938). In Thorpe's experiment, all the fertilizer was applied by broadcasting before planting, and although the early part of the season was favourable, heavy rains occurred in February which may have prevented the highest level of phosphate showing a significant increase over the second level (in this experiment 80 lbs. and 52 lbs. per acre respectively) when combined with the highest level of nitrogen.

The results also tend to support the hypothesis put forward to explain the failure of different levels of phosphate to show any effect on yield or quality

in the 1942–43 season (Tobacco Research Board Publication No. 7). If, as has been shown above, higher levels of phosphate can only exert their maximum effect in the presence of high nitrogen, then in a season when leaching is high, or when the availability of nitrogen is low, the effect of increased dressings of phosphate would be diminished.

Potash.

The highest level of potash had a depressing effect on both yield and value, the two lower levels giving significantly better yields than the highest level, while the intermediate level gave a better cash value than the higher level. This result may be due partly to the form in which potash was applied. As it was not possible to obtain sulphate of potash, the whole of the K_2O was applied in the form of muriate, and it is possible that the depression in yield at the highest level is due to an excess of chlorine rather than to the direct effect of K_2O.

Experiment S.

This experiment consisted of a test of three varieties, three levels of Nitrogen and three levels of compost in all combinations, giving a total of 27 treatment types. The treatments were as follows:—

Variety	Nitrogen	Compost
V_1 White Stem Orinoco ..	N_1 18 lbs. per acre	N C_1 0 tons per acre
V_2 Bonanza	N_2 27 lbs. per acre	N C_2 4 tons per acre
V_3 Gold Dollar	N_3 36 lbs. per acre	N C_3 8 tons per acre

The varieties were chosen on the basis of vigour, White Stem Orinoco being considered the most vigorous type, Bonanza intermediate and Gold Dollar the least vigorous. As it turned out, White Stem did not prove to be more vigorous than Bonanza in this particular season.

The other treatments were designed to test whether any interaction occurred between nitrogen and compost, and whether any material reduction in fertilizer could be made when high applications of compost were used. It was hoped, also, that these manurial treatments, likely to produce vigorous growth, in combination with the varieties would yield information as to the suitability of any of the varieties to any particular soil type.

Nitrogen was applied as $\frac{1}{3}$ Nitrate of Soda, $\frac{1}{3}$ Ammonium Sulphate and $\frac{1}{3}$ Bloodmeal.

Phosphate and Potash were kept constant, at 52 lbs. per acre and 32 lbs. per acre respectively, at which levels neither should have a limiting effect.

A chemical analysis of the compost was not made, but as the compost was made in a similar manner from the same ingredients as previous seasons, there was no reason to believe it differed markedly in chemical composition. An average analysis of these composts is given in Section II of this Report.

The compost was applied round the marker and lightly covered. One-half of the fertilizer dressing was applied subsequently, mixed with the soil and compost and hilling completed.

The experimental design was a $3 \times 3 \times 3$ Partially Confounded Arrangement in blocks of nine plots each with four replications, giving 36 replications of each main treatment.

The field chosen for the experiment was a second-year land of a good type of pink, sandy loam.

Planting, which took place on the 25th November, was followed by unfavourable conditions. The experiment was refilled on the 5th and 31st December, the final stand being good but uneven. The second application of fertilizer was applied on 31/12/43.

The results of the treatments and significant interactions are summarized in Tables IV, V and VI.

TABLE IV

Treatment	Yield per Acre *lbs.*	% of Mean	Price per Pound *pence*	% of Mean	Cash Value per Acre	% of Mean
White Stem Orinoco ..	742	103·6	6·95	102·2	£21 10 0	105·7
Bonanza	749	104·6	6·85	100·7	21 9 0	105·4
Gold Dollar	656	91·6	6·60	97·0	18 2 0	88·9
18 lbs. Nitrogen per acre	671	93·7	6·72	98·8	18 17 0	92·6
27 lbs. Nitrogen per acre	706	98·6	6·75	99·3	19 18 0	97·7
36 lbs. Nitrogen per acre	770	107·5	6·93	101·9	22 6 0	109·7
0 tons Compost per acre	723	101·0	6·67	98·09	20 4 0	99·3
4 tons Compost per acre	705	98·5	6·81	100·1	20 1 0	98·5
8 tons Compost per acre	719	100·4	6·93	101·9	20 16 0	102·2

	Yield	Price	Value
Mean of all Treatments ..	716 lbs.	6·80*d.*	£20 7 0
Standard Error	1·78%	0·69%	1·97%
Significant Differences ..	36 lbs. *or* 5·0%	0·13*d.* *or* 2·0%	£1 3 0 *or* 5·5%

Yield.

White Stem Orinoco and Bonanza better than Gold Dollar.
36 lbs. Nitrogen .. .. .. ,, ,, 27 lbs.
27 lbs. Nitrogen .. .. .. almost better than 18 lbs.

Price.

White Stem Orinoco and Bonanza better than Gold Dollar.
36 lbs. Nitrogen .. .. .. ,, ,, 18 or 27 lbs.
4 tons Compost .. .. .. ,, ,, no compost.
8 tons Compost .. .. .. almost better than 4 tons compost.

Value.

White Stem Orinoco and Bonanza better than Gold Dollar.
27 lbs. Nitrogen .. .. .. ,, ,, 18 lbs.
36 lbs. Nitrogen .. .. .. ,, ,, 27 lbs.

Two-Factor Interactions.

The two-factor interaction between compost and variety was significant. The results of this interaction are shown in Table V.

TABLE V

	C_1		C_2		C_3	
	Price per Pound *pence*	% of Mean	Price per Pound *pence*	% of Mean	Price per Pound *pence*	% of Mean
V_1	6·81	100·1	6·78	99·7	6·97	102·5
V_2	6·79	99·8	6·84	100·6	7·22	106·2
V_3	6·42	94·4	6·79	99·8	6·60	97·0

Mean .. .. 6·80*d.*
Standard Error .. .. 1·21%.
Significant Difference .. .. .. 0·25*d.* or 3·67% of mean.

Three-Factor Interactions.

The three-factor interaction between variety, compost and nitrogen was significant on the basis of average price. The results of this interaction are summarized in Table VI.

TABLE VI

		N_1			N_2			N_3		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
V_1	Price	6·69	6·79	6·73	6·79	6·67	6·75	6·94	6·89	7·42
	% of Mean	98·3	99·8	98·9	99·8	98·0	99·3	102·0	101·3	109·1
V_2	Price	6·48	6·67	7·36	7·12	6·67	7·09	6·77	7·18	7·20
	% of Mean	95·2	98·0	108·2	104·6	98·0	104·2	99·5	105·5	105·8
V_3	Price	6·53	6·86	6·36	6·14	6·72	6·83	6·58	6·79	6·62
	% of Mean	96·0	100·8	93·5	90·2	98·8	100·4	96·7	99·8	97·3

Mean .. .. 6·80*d.*
Standard Error .. .. 2·08%.
Significant Difference .. .. .. 0·40*d.* or 5·86% of mean.

Compared with other experiments, the average price is low, due largely to considerable damage caused by alternaria towards the end of the season.

DISCUSSION OF RESULTS

Varieties.

Both White Stem Orinoco and Bonanza outyielded Gold Dollar by a wide margin, demonstrating conclusively the lack of vigour of this variety. The former two varieties also gave better results on the basis of average price and value per acre. As far as could be ascertained, the lower price returned by Gold Dollar was due to a high percentage of short leaf, correlated with poor growth, rather than to any intrinsic differences in leaf quality compared with the other two varieties. It is very obvious that Gold Dollar is too weakly for the Trelawney soils, and until tested on heavier type soils, where it should make full growth, the potentialities of this variety cannot be assessed.

Nitrogen.

Thirty-six pounds of nitrogen per acre gave better results than either 27 or 18 lbs. per acre in yield, price and value. In yield, 27 lbs. nitrogen was significantly better than 18 lbs., and in value it almost reached the level of significance. Differences between nitrogen treatments were not so great as in previous seasons, probably owing to a considerable portion of the nitrogen being lost through leaching.

It is interesting to note that in spite of the fact that the low average price has been ascribed to the prevalence of alternaria, the highest level of nitrogen has returned the highest average. It is evident, therefore, that in this particular season, high dressings of nitrogen did not render the plant more susceptible to the fungus, but tended, if anything, to reduce the incidence. The higher price may, however, be correlated with better sized leaf rather than with an absence of "spot."

Compost.

Compost had no effect whatsoever on yield, but with each additional level an increase in average price occurred. Thus, 4 tons per acre gave significantly better price than no compost, and 8 tons gave a price almost significantly better than 4 tons.

Two previous tests with compost had shown an increase in yield compared with no compost, but both of these tests were made on soil which had probably lost a great portion of its organic matter. The results of these former experiments were as follows:—

In the season 1939–40, on a land carrying its fourth successive crop of tobacco, 4 tons of compost gave a significantly better yield than no compost, and 8 tons gave a significantly better yield than 4 tons. In the 1940–41 season, the test was made on a very light sand, which had been prepared for planting three years previously, but had not been used the first season. When the test was made the land was only carrying its second crop of tobacco, but from the point of view of weathering, was equivalent to third-year soil. In this season $3\frac{1}{2}$ tons gave a better yield than no compost, but 7 tons did not give a significantly better yield than $3\frac{1}{2}$ tons.

In both seasons composted treatments gave higher average prices than non-composted treatments.

It would seem, therefore, that the response to compost on the basis of yield is a measure of the exhaustion of the soil, and that the failure of compost to give increased yields in the past season was due to the soil being in good heart and not impoverished by erosion.

The consistent increase in average price shown over all these experiments when compost was used is, however, of great importance. This is particularly the case in the past season, when the lowering of average price was largely due to fungal diseases. Increased levels of nitrogen also gave increased average price, but in this case the yield per acre was also increased. The higher average might, therefore, be due to increased leaf length, or to a lower percentage of short grades. In the case of compost, however, the increase in average price was not accompanied by an increase in yield, so that it must be assumed that the increase in average price was due to an improvement in the intrinsic qualities of the leaf, apart from a mere size factor. It seems possible that compost has conferred upon the plant a measure of resistance to alternaria, the disease which caused the major portion of damage in this particular experiment.

In this connection, it is of interest that in another compost trial, described in section II of this Report, where little damage was caused by fungal diseases, there was no difference in price between composted and non-composted treatments.

The Interaction of Compost and Variety.

The results of this interaction, summarized in Table V, may be explained as follows:—

With V_1 (White Stem Orinoco) there was no significant difference in average price between 0 compost, 4 and 8 tons.

V_2 (Bonanza) showed no increase in price between 0 compost and 4 tons, but reacted strongly to 8 tons.

V_3 (Gold Dollar) showed a significant jump in price between 0 compost and 4 tons, but the 8-ton level showed a decrease and was, in fact, not significantly better than 0 compost.

The Three-Factor Interaction—Nitrogen × Variety × Compost.

Although two of the results of this interaction appear, at the moment, to be anomalous (N_2 V_2 C_1 and N_1 V_3 C_2), the general trend of the interaction appears to be as follows:—

With V_1 (White Stem Orinoco) there is no response to compost with the first and second levels of nitrogen, but when the third level of compost is combined with the third level of nitrogen, there is a significant increase in price over the other combinations.

With V_2 (Bonanza) over each level of nitrogen, a significant increase in price occurs with the highest level of compost, except for the anomaly mentioned above.

With V_3 (Gold Dollar) there is no response to increased compost with the first and third levels of nitrogen. There is, however, a significant increase from C_1 to C_3 with the second level of nitrogen.

It would seem, therefore, that the price of White Stem is little affected by compost, unless when combined with heavy dressings of nitrogen, and that to bring the best out of this variety both nitrogen and compost should be at high levels.

Bonanza, on the other hand, shows much more response to compost, with the result that dressings of compost bring about an increase in price independently of the nitrogen present. The increase is, in fact, most marked with low nitrogen.

The reaction of Gold Dollar to increased compost, with the intermediate levels of nitrogen but not with the lowest or highest nitrogen, is difficult to understand.

These two experiments show that the varieties are not all alike in their manurial requirements, and that to obtain the best results any particular variety may require its own special combination of fertilizer ingredients to show to the best advantage.

Both of the experiments are intended to continue for some years, and it is hoped that as information accumulates, light will be thrown on many problems concerning the interaction of variety with fertilizers or soil types.

V

ROOT KNOT NEMATODE

FIELD EXPERIMENTS

Field trials, designed to find methods of controlling the nematode or of reducing the effect on the crop of its presence in the soil, have been prosecuted or Thurbar Farm according to the plan outlined in last year's Report.

To avoid repetition, it should be noted that, unless otherwise stated, all the plots were under tobacco the previous season, following the ploughing of the soil from the weed fallow in which it had lain for several years. With a similar reservation, all the plots were planted and filled in on the same dates and received the same quantities of fertilizer. All the plots or sub-plots were $\frac{1}{40}$ of an acre in size.

Planting and filling in dates were: November 29th (largely a failure), December 5th, December 12th and December 30th.

Fertilizer was applied as follows:—

December 14th	..	Standard Mixture at 150 lbs. per acre.
January 7th	..	Standard Mixture at 150 lbs. per acre.
February 2nd	..	Nitrogenous fertilizer (10–5–7) at 100 lbs. per acre.
		Total fertilizer: 400 lbs. per acre.

The fertilizer was applied in a ring round each plant, and lightly worked into the soil.

With the exception of the dhal trials, all the plots were free from crop remnants and weeds from May until the rains, but, as is the case with many tobacco lands, living roots of forest trees, such as mnondo (*Isoberlinia globiflora*), mfuti (*Brachystegia woodiana*) and other species, still persisted in many places.

The infestation of the test tobacco plants was recorded at maturity, *i.e.*, after harvest. The basis of the classification is: Heavy, over 50% of the roots galled; Medium, 25% to 50% of the roots galled; Light, under 25% of the roots galled; nil, not infested.

A method of expressing the infestation in a single figure is to give the values 4, 2, 1 and 0 to "heavy," "medium," "light" and "nil" respectively, and to express the sum in percentage of the total possible infestation on this basis, which is 4 × number of plants. These values are given in the following tables.

It is to be borne in mind that the nematode passes through several generations during the growing season and that the females produce a large number of eggs. In the case of a susceptible crop such as tobacco, the infestation at the end of the growing season is therefore liable to be many times greater than it was at the beginning.

ROTATIONS AND ADDITIONAL WINTER PLOUGHINGS

Trials relative to the above are combined in one Series, the main objects in view being to ascertain—

(1) Whether additional ploughings at varying dates in the dry season assist in reducing the nematode population in the soil;
(2) whether rotation with resistant crops over a varying number of seasons gives commercial control of the nematode under Southern Rhodesian conditions;

(3) whether a combination of ploughing and rotation gives better results than either of these treatments individually;
(4) whether commercial control, if obtained, is effective for more than one season in respect to tobacco, provided that bare fallow is maintained during the dry season.

The experimental plots are situated on the "X" land described in last year's Report. They consist of four blocks, each consisting of three main plots, each of which is again divided into six sub-plots, making a total of 72 sub-plots.

The main plots provide for three different winter treatments of the soil, namely, (1) One ploughing only, in May; (2) Three ploughings, in May, June and July respectively; (3) Three ploughings in May, September and October respectively. The layout of these treatments is randomized within the blocks.

The sub-plots provide for two series of rotations, namely, with (1) resistant crops and (2) susceptible crops, and for three periods in each case, namely, one, two and three seasons before tobacco. The layout of these treatments is randomized within the main plots.

The rotation trials are thus superimposed upon the winter ploughing trials and the layout provides for four replications of each winter ploughing treatment and 12 replications of each rotation treatment.

The term "ploughing" is used throughout for convenience. It is not practicable to plough such small plots individually and the soil is therefore dug over with hoes under close supervision, care being taken to see that it is worked to a depth of fully 5 inches.

The rotation trials were started in the 1942–43 season with Sunn Hemp and Kaffir Beans (cowpeas) as resistant and susceptible crops respectively. The Sunn Hemp grew well, taking almost complete possession of the soil and reaching a height of six or more feet. The Kaffir Beans made fair growth only, more or less covering the soil but lacking luxuriance as a whole. Both crops were dug into the soil at the beginning of May, 1943.

The winter ploughing treatments were carried out, as planned, during the dry season of 1943.

The 24 plots allocated to the one season rotation trials were planted with test tobacco for the 1943–44 growing season, the soil being ridged for this purpose.

The return from the test tobacco with reference to the winter ploughing treatments were as follows:—

TABLE I

INFESTATION AND YIELD OF TOBACCO FOLLOWING DIFFERENT WINTER PLOUGHING TREATMENTS

No. and Months of Ploughings	Means—All Plots*			
	Infest. %. 4, 2, 1, 0 Values	% of Mean	Yield, lbs. p.a.	% of Mean
1. — May	51·4	104·1	411	99·2
3. May, June, July	49·4	100·0	431	104·0
3. May, September, October	47·5	96·2	401	96·8

* *i.e.*, including both Sunn Hemp and Kaffir Bean treatments.

There are no significant differences between treatments, in fact, the differences are insufficient to furnish even an indication of any benefit from the additional ploughings.

The returns with reference to the rotation treatments were as follows:—

TABLE II

INFESTATION AND YIELD OF TOBACCO FOLLOWING DIFFERENT ROTATION TREATMENTS

Treatment	Infestation Means—%					Mean Stand %	Mean Yield lbs. p.a.
	Heavy	Medium	Light	Nil	4, 2, 1, 0 Values		
f. Sunn Hemp ..	3·5	11·4	21·2	63·9	14·5	96·4	459·0
S.E.	0·99	—	—	—	1·77	—	34·96
f. Kaffir Beans ..	75·4	13·5	8·2	2·9	84·2	89·7	369·0
S.E.	3·33	—	—	—	2·44	—	28·98

These results are also shown diagrammatically at Fig. 1.

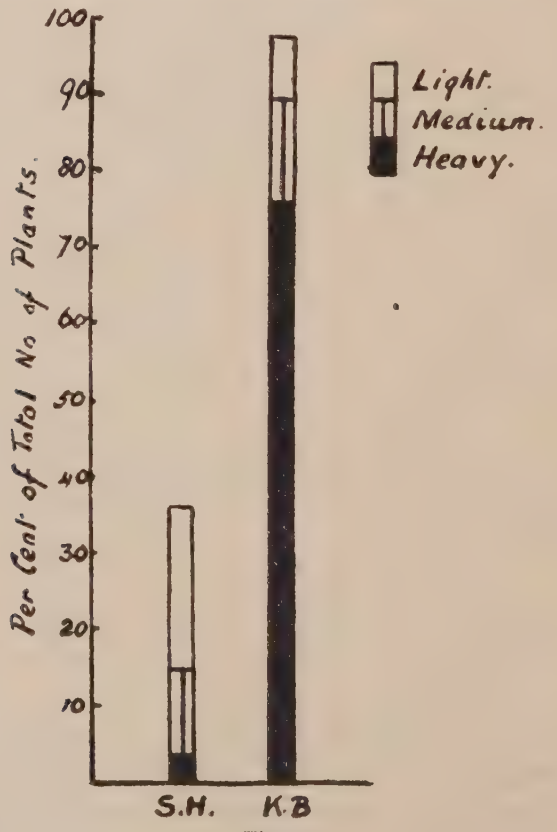


Fig. 1.

The difference between the infestations is highly significant. The difference between the yields falls short of significance by "t" at the 5% point.

The lower stand of plants following Kaffir Beans was mainly due to deaths from nematode attack on one plot, which secured only a 52% stand. A number of plants which died on this plot were examined from time to time and all were found to be very heavily galled without indication of insect attack. The infestation of this plot at 4, 2, 1, 0 values was 92·5% and many plants which survived were badly stunted. In addition to the very heavy infestation, there is no doubt that the fertility of this plot was very poor.

It may be asked whether the growing of Sunn Hemp for one season had actually reduced the previous infestation of the soil. The growing of Kaffir Beans, which are highly susceptible, may, of course, be expected to have increased it.

Whilst it is not safe to make close comparisons between one crop and another, or between one season and another, it may be stated that at the end of the 1943 growing season twelve Kaffir Bean plants were taken at random from each of 36 plots in this series and that 47% were recorded as infested, as against 36% tobacco plants infested this year following Sunn Hemp. The respective percentages of *heavily* infested plants, which give a better measure of the respective soil infestations, were 13·2% and 3·5%. The indications are, therefore, that the growing of Sunn Hemp had reduced the previous infestation appreciably, but further evidence in this connection will accumulate as the trials proceed.

Discussion.

The degree of infestation of the tobacco plants following Sunn Hemp may be regarded as very satisfactory, especially when it is recalled that the figures refer to plants which had grown to maturity in the infested soil. The infestation was certainly too light to have had any considerable effect on the crop.

It should be noted in this connection that the effect on the nematode population of Sunn Hemp, when turned in as a green manuring crop, may be due to any of the following, namely, (1) Starvation of the nematode through absence of suitable host-plants during the wet season, (2) the addition of a considerable quantity of organic matter to the soil, (3) a combination of the foregoing.

In order to obtain further information on the matter, it has been planned to lay down a parallel series of rotation trials with Sunn Hemp next season, the crop being (1) reaped and the stubble turned in, (2) turned in early, and (3) turned in late. These trials should reveal any benefit with regard to infestation which may be due to additional organic matter.

The yields from the trial under discussion are very poor. It is apparent that the inherent fertility of the soil concerned, a whitish sand, is distinctly low, and there was, no doubt, substantial loss of fertilizer through leaching due to the heavy and continuous rains. The failure of the very lightly infested tobacco following Sunn Hemp, dug in, to respond markedly to this treatment of the soil may be due to the fact that the crop was turned under after the soil had dried, so that decomposition did not set in until the following rains. The organic matter supplied would probably not have been fully available to a rapidly maturing crop such as tobacco.

A better test of the effect on yield of Sunn Hemp and other resistant crops dug into infested soil should be provided by a larger series of rotation trials maturing next season. In this case the Sunn Hemp was turned under at the end of February this year and appears to have broken down to a large extent before the soil dried.

The absence of benefit from the additional winter ploughings is in harmony with certain complementary observations. This treatment is intended to dry out the soil more thoroughly and so reduce the nematode population by desiccation. In this connection see soil moisture determinations on page 55.

Dhal v. Weed Fallow (One Year).

The experiments to ascertain the value of dhal against the nematode provide for one, two and three years respectively under this crop. The planting of dhal is regarded as an alternative to leaving the land in weed fallow, and a parallel series of plots have accordingly been left to weed growth. The layout is randomized.

The one-year treatment trials, consisting of four plots each under dhal and weeds, matured during the present year.

Dhal normally takes full possession of the soil by the second year, but for the purpose of these trials was kept clear of weeds by frequent hoeing during the first year. The dhal plants were dug out and the fallen leaves dug into the soil on November 11th, the weeds in the parallel plots being dug in on the same day. The soil was ridged for planting.

The results may be stated very simply to the effect that the infestation of the tobacco plants following both dhal and weeds was identical in each case at 4, 2, 1, 0 values, namely, 33·75%. There was also no significant difference in the yields, which were light, namely, f. Dhal, 482 lbs. per acre; f. Weeds, 507 lbs. per acre.

The strain of dhal used was indicated in last year's Report. It had proved to be highly resistant in pot tests. The plants from the field plots were examined after being lifted and infestation was found in only one out of over 400 plants. This plant was, however, freely galled and numerous females and egg masses of the nematode were present. It would appear that this is an instance of breakdown of resistance due either to mutation or segregation.

A list of the weeds which took possession of the weed fallow plots is given in Appendix II.

Applications of Compost.

Two blocks of 16 plots each, giving four replications of each treatment, were used during the season for further tests of the effect of compost applications.

Exp. 1.—This was a repetition of last year's trial, the same block of "X" land being used and each plot receiving the same treatment as last year, namely, 0, 4, 8 and 16 tons of compost per acre respectively. The layout in this block is randomized.

The compost was broadcast over the plots on November 19th and 20th and was lightly hoed in. On November 22nd the soil was hoed up into hills, without previous application of fertilizer.

The result of this trial was as follows:—

TABLE III. – INFESTATION AND YIELD OF TOBACCO FOLLOWING APPLICATION OF DIFFERENT QUANTITIES OF COMPOST (*Exp.* 1)

Tons per Acre	Infestation Means—%					Mean Stand %	Mean Yield lbs. p.a.
	Heavy	Medium	Light	Nil	4, 2, 1, 0 Values		
0	26·2	23·5	25·6	24·7	44·3	97·7	518
4	27·4	27·6	28·6	16·4	48·5	99·0	545
8	33·8	27·7	25·7	12·8	54·3	96·3	541
16	28·4	27·8	27·2	16·6	47·0	96·7	613

There is no significant difference in either infestation or yield following the different treatments.

Statements have been made to the effect that, whatever happens during the first season, a second season of compost application brings about a radical reduction of nematode in the soil. The above results are far from bearing out this contention. At 4, 2, 1, 0 values the corresponding infestations last year were: 29·3%, 45·0%, 50·3%, 41·0%, which certainly does not indicate any decrease this year. As will be seen later, planting on hills compared with planting on ridges, as last year, tends to decrease the infestation, especially in the heavy class, and, as far as the plots which received compost are concerned, the returns for this year in this class are much the same as last year.

Exp. 2.—The land used for this experiment was part of the "Z" land, planted to tobacco and inoculated with nematode in the 1942–43 season.

The layout in this case was a Latin Square, and the applications of compost were the same as those given in Exp. 1, namely, 0, 4, 8 and 16 tons per acre respectively.

The method of application was, however, different, a measure being used to place the compost round the markers in the required quantities. The compost was then mixed with the soil, forming a slight mound. Standard fertilizer was then applied round the markers at the rate of 100 lbs. per acre, and the hills were hoed up in the usual way.

The compost was applied and hoed in on November 19th and 20th, the fertilizer being applied and the hills completed on November 22nd. The first planting of tobacco on November 29th was a complete failure, but the later plantings produced a good stand. Additional Standard fertilizer was given at the rate of 150 lbs. per acre on January 6th and 100 lbs. per acre of Nitrogenous fertilizer (10–5–7) was given on February 2nd, making a total of 350 lbs. of fertilizer per acre.

TABLE IV

INFESTATION AND YIELD OF TOBACCO FOLLOWING APPLICATION OF DIFFERENT QUANTITIES OF COMPOST (*Exp.* 2)

Tons per Acre	Infestation Means—%					Mean Stand %	Mean Yield lbs. p.a.
	Heavy	Medium	Light	Nil	4, 2, 1, 0 Values		
0	28·5	32·5	29·6	9·4	52·3	99·4	542
4	32·9	29·0	30·4	7·8	55·0	99·7	588
8	30·0	25·8	34·9	9·3	51·8	94·4	593
16	27·7	24·0	34·4	13·9	48·3	95·6	625

There is no significant difference in the infestation figures.

The differences in yield are also not significant by "Z", and this is, moreover, true if the two experiments are combined as one, giving eight replications of each treatment.

Results to date, therefore, fail to support the view that applications of compost, at least in the quantities applied in these experiments, materially reduce nematode infestation. There are indications of some benefit in respect

to yield from the heaviest application, namely, 16 tons per acre, but this would appear to be an uneconomic quantity.

It is, however, to be emphasized that the trials in this connection have been made so far only in two seasons of heavy and frequent rainfall, and that different results might be recorded under drier growing conditions. It is hoped, therefore, to repeat these tests next season, and possibly later.

Clean v. Infested Seedlings.

This experiment was designed to demonstrate the anticipated difference in severity of infestation when clean and infested seedlings respectively are planted in infested soil.

Eight plots were used, giving four replications with the treatments alternated, and the soil was ridged for planting. One hundred plants from the bed in which the infested seedlings were raised were examined and proved to be 100% infested.

TABLE V

INFESTATION AND YIELD OF TOBACCO FROM (1) CLEAN AND (2) INFESTED SEEDLINGS

Treatment	Infestation Means—%					Mean Stand %	Mean Yield lbs. p.a.
	Heavy	Medium	Light	Nil	4, 2, 1, 0 Values		
Clean	84·3	10·4	4·8	0·5	90·8	90·0	394
S.E.	4·79	—	—	—	2·94	—	—
Infested	96·1	3·6	0·3	—	98·0	78·5	303
S.E.	1·39	—	—	—	0·67	—	—

The difference in the infestation is not significant by "t" at 5%. The difference in the yields is also non-significant, the returns from the different plots being very uneven.

This demonstration lost greatly in value through the abnormally high infestation of the soil, which had carried Kaffir Beans the previous year. The very high rate of infestation of the clean seedlings left insufficient margin for comparison with the infested seedlings. This experiment needs repeating on less heavily infested and, if possible, less unevenly fertile soil.

Hills and Ridges.

The object of this trial was to test Mr. A. D. Collins' statement (*see* R.A.J., June, 1938) that, on infested soil, planting on hills, made with not more than the top two inches of soil, gives better results than planting on ridges.

Eight plots of "Z" land, giving four replications, were used for the experiment, the treatments being alternated.

In the case of the hilling method, Standard fertilizer was applied round the markers at the rate of 200 lbs. per acre on November 24th and the hills were made over this at once, as directed by Mr. A. D. Collins. A further application consisted of 100 lbs. per acre of Standard mixture on January 6th, worked in round the plants, making 300 lbs. Standard fertilizer in all.

In the case of the ridging method, fertilizer was only applied after planting, namely, at the rate of 150 lbs. per acre on December 14th and a similar quantity on January 6th, making a total of 300 lbs. Standard mixture.

These plots were first planted on December 5th and were filled in on December 18th and 30th, as was done elsewhere.

TABLE VI

INFESTATION AND YIELD OF TOBACCO PLANTED ON (1) HILLS AND (2) RIDGES

Treatment	Infestation Means—%					Mean Stand %	Mean Yield lbs. p.a.
	Heavy	Medium	Light	Nil	4, 2, 1, 0 Values		
Hills	36·7	34·9	21·4	7·0	57·9	98·5	418
S.E.	5·80	—	—	—	4·27	—	—
Ridges	58·6	22·4	13·1	5·9	73·1	98·8	403
S.E.	3·76	—	—	—	2·84	—	—

The method of planting under test is designed to avoid *heavy* infestation and contains no element which could be expected to avert infestation altogether. It is the proportion of heavily infested plants, therefore, which is of importance. This is just significantly in favour of the hilling method.

There is another measure of the lighter infestation of the hilled plots. Heavily infested plants tend to die rapidly with the advent of dry weather at the end of the growing season. The plants in this trial were lifted for examination on April 8th, 23 days after any considerable rain had fallen. On this date 30·2% (S.E. 4·79) of the plants in the ridged plots were already dead and dry, as against 8·5% (S.E. 1·84) in the hilled plots. The difference is significant.

This trial, therefore, furnishes evidence of appreciable advantage from planting on hills compared with planting on ridges in the case of nematode infested soil.

The theory underlying this method of avoiding the worst effects of the presence of nematode in the soil has been elaborated by Mr. A. D. Collins (*loc. cit.*). The top two inches of soil were presumed to be more or less free from nematode in the late dry season due to penetration of the sun's heat, that is, of course, in the case of soil which has not been disturbed for some considerable period. This presumption has been corroborated substantially by experiments carried out at this Station (see later). The tobacco is thus planted in more or less nematode-free soil, which has the additional advantage of the maximum humus content, and is provided with an immediately accessible supply of fertilizer. It is, presumably, able to make growth and acquire vigour before the roots penetrate to the infested layer beneath or the nematode rises in the soil. Infestation should, in fact, be delayed and rendered less complete, so that the plant is less injured.

Due, presumably, to the nature of the season, the advantage indicated was not reflected in the yield in this particular experiment. Further trials are projected.

General Discussion of Field Trials.

The figures obtained from the field trials show no consistent correlation between infestation and yield. In fact, a number of striking anomalies occurred, heavily infested plots producing a much greater weight of leaf than others, in the same series, with a very light infestation. This can only be attributed to the character of the season, with its heavy and frequent rains and absence of any prolonged spells of dry weather. This, undoubtedly, had a depressing effect on yield generally, whilst at the same time saving the infested plants from the worst effects of nematode attack, which are manifested under comparatively dry growing conditions. In other words, compared with a less rainy season, the past season lowered the yield of the clean and lightly infested plants and raised that of the more heavily infested plants, with the result that there was a greatly reduced difference between the yields from the two categories. In such circumstances the great variation in fertility between plots would fully account for the anomalies indicated above, and for the general lack of consistent correlation between infestation and yield.

It appears to be the general experience that in suitable seasons tobacco shows a very considerable degree of tolerance of infestation and that, under such conditions, it is quite possible to produce a profitable crop on fairly heavily infested soil. As a direct observation it may be stated that when the experimental plants were being examined at the end of the past growing season, many well-grown plants were found to have their roots heavily galled, showing that heavy infestation does not, under all conditions, seriously inhibit growth.

In a growing season of low intermittent rainfall, the effect on growth and yield of heavy infestation is likely to be much more substantial.

Bearing in mind that all the experimental plots were kept, or remained, free from weeds for fully six months through the dry season, the lack of any profound effect on the nematode population in the plots, which had carried susceptible crops the previous season, is noteworthy. A six months' bare fallow, even in the winter, is recorded in various countries as reducing the nematode very considerably (*e.g.*, Le Roux and Stofberg), although better results have been recorded from bare fallow through the summer. The presence in many places of lingering roots of forest trees might be suspected of having some effect in this connection. *Mnondo*, for instance, is known to be a host of the nematode. Survival of nematode in numbers was not, however, correlated with the presence of such roots in the soil, but occurred generally throughout the plots which had carried susceptible crops. It is evident that the nematode, in this Colony at least, is adapted to surviving the dry season without breeding, and it may be remarked that if this were not so, its control would be a very simple matter.

Summary.

The following results have been obtained from the field trials during the past season:—

(1) Sunn hemp has given promise of being a highly effective rotation crop for controlling nematode;
(2) Planting on hills with pre-fertilization appreciably reduced the proportion of heavily infested plants compared with planting on ridges;
(3) Applications of compost in economic quantities did not affect infestation nor, in a sufficient degree, yield under the prevailing conditions;
(4) Additional winter ploughings conferred no benefit;
(5) One year under dhal showed no advantage over leaving the land in weed fallow;
(6) Six months' bare fallow through the winter failed to effect commercial control of the nematode.

NOTES ON THE RESISTANCE OR SUSCEPTIBILITY OF VARIOUS CROPS

Dhal.

It has already been mentioned that using the locally available strain of dhal one plant out of some 400 grown in infested soil for one year in the field showed considerable galling and infestation, whilst the remainder of the plants appeared to be clean. Dhal (*Cajanus indicus*) is not specifically resistant to the nematode, certain varieties only showing high resistance. More completely resistant strains than that tested may possibly be procurable.

A variety termed "Black Seeded Dhal," from the Agricultural Experiment Station, Salisbury, was tested in pots during the year and ten plants were grown in infested soil in the field. Very slight infestation was recorded in the pot tests, but none in the field test.

Cotton.

The strain of cotton, 9 L 34, of which seed was supplied by the Cotton Breeding Station, Gatooma, was tested last year in very heavily infested and repeatedly inoculated soil in pots. Seventeen plants were grown for over three months and failed to reveal any infestation at the end of the period. On 25/11/43 four plots were planted at Thurbar for a special trial of this strain as a rotation crop for controlling nematode. The plants, 1,230 in all, were lifted on 17/5/44 and the roots were examined individually, without any sign of galling being found. There appears to be little doubt, therefore, that this strain of cotton is very highly resistant to nematode attack, which is a discovery of some importance. Most varieties of cotton are regarded as susceptible.

Kaffir Beans (*Vigna*).

Certain tobacco growers appear to be under the impression that the locally-grown kaffir bean is either not much attacked by the nematode, or is sufficiently tolerant to produce a good crop in spite of attack. Experience during the past two seasons does not bear out either of these views. The plants not only became very heavily galled, but undoubtedly suffered severely in many instances, young plants being often killed outright. On some plots three seedings failed to produce a 50% stand. There is ample evidence that this strain of kaffir bean is not a crop to grow on infested soil either in rotation with tobacco, or for its own yield.

Sunflowers.

Sunflowers are very readily attacked and gall freely. Twelve plots were planted during the past season in rotation trials, and all showed heavy infestation. Considerable tolerance of attack was, however, exhibited under prevailing seasonal conditions, many massive plants, 7–9 feet high, being produced on heavily galled roots. Tolerance might, however, be less conspicuous in a drier season.

Velvet Beans.

Pot and field tests have shown three varieties of velvet beans, namely, "Somerset," "Marbillee" and "Jubilack," all to be highly resistant.

Soya Beans.

Seven strains of soya beans were submitted by the Manager, Agricultural Experiment Station, Salisbury, for test. The strains were: (1) Hernon, No. 18; (2) Hernon, No. 55; (3) Hernon, No. 107; (4) Jubiltan, No. 65; (5) Jubiltan, No. 77; (6) Jubiltan, No. 109; and (7) Potchefstroom, No. 184. Tests were made in pots and in the field. All the strains became heavily infested.

NATIVE AND WEED HOST PLANTS

A number of additions have been made to the host list published in last year's Report, and will be found in Appendix I of the present Report.

Further study by botanists of specimens submitted by the writer have led to the alteration of some of the names previously given, whilst other names are considered to be incorrect, although no alternative identification has as yet been made.

There remain some common weeds and veld plants which so far have not been identified at all.

Further notes on the occurrence and habits of the weeds of tobacco soils have been made during the year.

INFESTATION OF SEED-BEDS FROM STREAMS

The danger of stream water harbouring nematode has received considerable attention. One experiment was carried out with water from a strongly suspected stream, using both clear water and water mixed with mud from the bottom of the pool near the bank. The watering was continued for 113 days, *i.e.*, from October 14th to February 4th, at the end of which period the plants showed no sign of infestation. Collins (J. C.) obtained one positive result with water from the same stream mixed with mud from near the bank (Annual Report of Tobacco Research Board for 1937).

Experiments of this nature are of no value unless a positive result is obtained, as only a very small quantity of water can be tested under properly controlled conditions, compared with the thousands of gallons annually applied to seed-beds on a single tobacco farm.

The experiment was not repeated because, in point of fact, there is no room for doubt that streams may be dangerous from the nematode standpoint, and there does not seem to be much point in endeavouring to demonstrate the fact by small-scale tests, the great majority of which are likely to give negative results.

There is one very obvious way in which streams may cause trouble in this respect. Floodwater is a notoriously effective agent in transporting nematode. Consequently, any stream which receives floodwater from infested soil is liable to receive large numbers of nematode larvae with it, and to carry them down-stream. Many of these larvae are liable to be deposited on land flooded by the stream itself, and such land commonly bears host plants of the nematode. Consequently, any land within the flood limits of a stream is particularly liable to become infested and provides a decidedly dangerous site for seed-beds. Infested plants have been found in this situation both by Collins (*loc. cit.*) and the writer. Unfortunately, the most suitable soil for seed-beds is frequently to be found in this dangerous position, and it is thought that the deservedly bad reputation of certain streams may be largely due to seed-beds being made in soil already infested by their floodwaters.

The other aspect of the problem is the danger of introducing nematode to clean soil with water drawn from streams for seed-bed purposes. It would swell this Report unduly to describe in detail various experiments carried out to obtain information bearing on this problem, but the results may be given briefly.

The following facts need to be borne in mind, namely, that the only form of nematode capable of attacking plants is the *larva*, *i.e.*, the young nematode as it hatches from the egg, and, secondly, that the eggs are normally embedded in, or attached to, the roots of the host plant.

One important fact is that the larvae, the eggs themselves and sodden pieces of root all sink in water and, in a reasonably clear pool, are soon deposited on the bottom.

The larvae are unable to assimilate oxygen from water and eventually drown. The period required for drowning varies with the individual, and to a small extent with the temperature of the water. There is, however, a more important factor affecting the period of survival and that is the amount of light to which the larva is exposed. No larvae have survived for eight days in water when exposed to diffused daylight in the laboratory. In the dark, at the same summer temperature, occasional larvae have survived for 24 days and possibly a few days longer. In the dark, in the winter, occasional larvae have survived for 33 days. Larvae at the bottom of a pool would almost certainly bury themselves in the mud, so that dark conditions would prevail.

The eggs hatch in due course when immersed in water. Pieces of root containing egg masses kept under water have continued to release larvae over a period of fully 70 days, but it is not certain that actual hatching extended over so long a period, as many larvae may not have left the root tissues for some time after hatching.

As a final experiment heavily infested roots were buried in soil in pots, with the drainage holes corked up, and the soil was kept submerged in rainwater, the top of the soil being an inch or more below the surface of the water. At intervals of 15 days the cork was removed from one pot and as soon as the soil had drained sufficiently sunflower seeds were planted to ascertain if living larvae remained. This provided a test of the period of submergence necessary to cover the hatching of all the eggs, and the subsequent drowning of the hatched larvae in the dark. The test plants became heavily galled in all the pots up to 60 days of submergence. By the seventy-fifth day very few nematodes survived, but some survival was indicated after 90 days' submergence in two separate experiments. After 105 days' submergence, no survival was registered.

The experiments are not quite completed at the time of writing, but it is evident that a very small number of larvae might survive in a stream-pool about 100 days after the last flooding rains, these larvae needing to have been hatched from infested pieces of root brought down at that time. The vast majority of hatched larvae would, however, have perished long before the end of the period, and there is no suggestion that any larvae hatching from pieces of root brought down by the last floods could survive until the next seed-bed season.

The danger, in short, lies with the *banks* of streams, where nematode can persist indefinitely and from which infested soil is liable to be dislodged by mechanical means at any time into the water. If water is drawn from a pool in such a way as to include soil from the bank, the likelihood of carrying nematode to the seed-beds is obvious.

If a stream-pool has to be used the best procedure, as already suggested by Collins (*loc. cit.*) would seem to be to fix the intake of a pump in such a position as to draw only clear water from the middle of the pool. It would be best to pump it into a brick reservoir. A fine strainer, frequently cleaned, would help to keep out any infested pieces of root, in the event of such being brought up by the pump. Moreover, seeing that all sources of infestation sink in water, an obvious additional safeguard would be to fix the outlet pipe from the reservoir, say, 12 inches above the floor. Finally, the longer the water stands in the reservoir before being used, the less will be the likelihood of nematode surviving.

Stormwater dams are probably a good deal safer than streams as sources of water for seed-beds, due to the fact that the immediate surroundings of their retreating margins have usually been submerged for a period sufficiently long to preclude the possibility of the persistence of nematode in the soil.

Some attention has been given to the question of killing the nematode in water by the addition of some chemical, but the results of experiments have not been promising. It is obvious that to be generally applicable the chemical would need to kill both larvae and eggs quickly, whilst, of course, not injuring the seedlings, nor being too expensive. The investigation is being continued, but as present there is nothing of value to report.

USE OF INFESTED TOBACCO PLANTS FOR COMPOST, ETC.

Experiments have been carried out to determine how long the nematode will survive in the roots after tobacco plants have been uprooted.

The first plants used were lifted on April 3rd and either left lying on the soil in the open or taken to the laboratory and kept in the shade. Survival of nematode was tested by burying the complete root systems of the plants in sterilized soil in plots and planting sunflowers. For each series, *i.e.*, sun or shade, and for each period since uprooting, four pots were used for the infested roots, with two control pots, in which no roots were buried.

Considerable survival was shown in the case of plants which had been uprooted for seven days, whether left in the open or kept in the shade. A small survival was revealed in the case of plants kept in the shade for 14 days, but none in the case of plants left in the open for that period.

A further lot of infested tobacco plants were lifted on May 30th, and were left in the open for 21 days. Tests, as above, showed no survival of nematode.

It appears, therefore, that, allowing a safety margin of one week, infested tobacco plants uprooted and left lying in the open for three weeks may safely be used for making compost.

DEPTH OF NEMATODE-FREE LAYER OF SOIL IN DRY SEASON

At Thurbar some tobacco plants were left standing over the dry season to indicate the presence or otherwise of nematode, and spots were selected close to heavily-infested plants, but away from their roots. Each month, from May to November, soil was removed inch by inch to a depth of 6 inches and separate pots were filled with soil from each layer. Sunflowers were then planted in the pots as a test for the presence of nematode.

No appreciable rain fell from May until November 4th, after which date wet season conditions prevailed. The results of the tests were as follows:—

May 21st ..	All layers infested.
June 21st ..	All layers infested.
July 21st ..	Top 1 inch free; remaining 5 inches infested.
Aug. 21st ..	Top 1 inch free; remaining 5 inches infested.
Sept. 21st ..	Top 3 inches free; remaining 3 inches infested.
Oct. 19th ..	Top 4 inches free; remaining 2 inches infested.
Nov. 4th ..	Rains commenced.
Nov. 24th ..	Top 1 inch free; remaining 5 inches infested.
Jan. 3rd ..	All layers infested.

To the above records may be added the results of two similar tests made in 1942 on a different piece of land, as follows:—

July 8th .. Top 2 inches free; remaining 4 inches infested.

Oct. 2nd .. Top 4 inches free; remaining 2 inches infested.

The above records refer to soil which had not been ploughed since the previous wet season.

Comparative tests showed that the position was not quite so favourable in the case of soil which had been ploughed after harvest. On September 25th a series of tests similar to the above were made with soil which had been ploughed the previous May, and remained loose. Only the top one-inch layer proved to be quite free from nematode, although there was only a trace of infestation in the second one-inch layer. This compares with three inches free in unploughed soil about the same date.

On the same date pots were filled with soil from the top two inches on three other plots ploughed the previous May, two pots to each plot. Three out of the six plots showed the presence of a few nematodes.

On October 22nd inch by inch tests with soil from two plots ploughed the previous May gave negative results for the top two inches only, although infestation of the third inch was very slight.

In general, the results of these tests are consistent with the theory underlying A. D. Collins' method of nematode control, provided that the hills are made up before the rains. They also indicate the desirability of planting infested land as early as possible so that the plants may become established and make some root before the nematode level rises in the soil.

The cause of the absence of nematode from a shallow layer at the surface of the soil late in the dry season may be due as much to penetration of the sun's heat as to dryness. Three thermometers were kept in loose soil from September to November with their bulbs buried to a depth of 2, 3 and 4 inches respectively. Readings were taken during the hottest periods of particularly hot days. The highest temperatures were registered at 3 p.m. on November 2nd, namely—

2 inches	116·6°F.
3 inches	107·6°F.
4 inches	100·4°F.

These readings were closely approached on a number of other days. On November 2nd a temperature of over 107°F. was maintained for a period of five hours at 2 inches, and of 105°F. or over for fully three hours (possibly four hours) at 3 inches. Such temperatures are amply sufficient to destroy any nematode larvae in the soil.

As far as moisture, or the lack of it, is concerned, the presence of nematode was demonstrated on four occasions in soil which analysis showed to contain no more than 0·5% to 0·7% of total water to dry weight of soil.

WATER CONTENT OF SOIL IN DRY SEASON

(1) Normal Drying-out of Soil.

Certain measurements of the amount and distribution of water in the soil, as affected by the progress of the dry season, were made in 1943 with the object of increasing our knowledge of the environment of the nematode under Southern Rhodesian conditions.

The rainfall records bearing on the following figures show a total for the 1942–43 season of 43·83 inches. No appreciable precipitation occurred after May 1st.

The sites chosen for taking the successive samples were within a few feet of one another. A hole was dug and the soil was removed with a flat spade as nearly as possible inch by inch from the surface, soil from each layer being transferred immediately to an airtight container. The figures given represent the mean of three 25-grm. samples from each container.

(1) *Ploughed Land on Research Station.* This land had been under continuous cultivation for six years and had last been ploughed in May, 1943. The soil is a light sandy loam, with a yellow sub-soil appearing at about eight inches below the surface.

TABLE VII

PLOUGHED LAND ON RESEARCH STATION

% Weight of Water to Dry Soil

One-inch Layers from Surface	Dates of Samples				
	June 28th	July 29th	Sept. 9th	Sept. 28th	Oct. 27th
1st ..	0·44	0·33	0·48	0·30	0·12
2nd ..	0·89	0·60	1·41	0·75	0·20
3rd ..	1·89	1·80	2·24	1·03	0·43
4th ..	3·99	5·21	4·53	2·10	0·59
5th ..	4·37	7·05	5·18	3·80	1·00
6th ..	6·37	6·92	5·97	5·57	1·39
7th ..	6·17	6·81	6·26	5·90	2·52
8th ..	6·86	6·14	6·93	5·92	2·75
9th ..	7·03	6·29	6·34	5·70	3·19
10th ..	6·71	6·20	5·10	5·14	2·97
11th ..	6·57	6·43	5·19	4·37	2·97
12th ..	6·47	6·61	5·16	4·48	3·15
Mean of 12″	4·81	5·01	4·57	3·76	1·78
Mean of top 6″ ..	2·99	3·65	3·38	2·26	0·62

(2) *Unploughed Land on Thurbar.* This land had lain in weed fallow for several years, and was then ploughed once in October, 1942. It had not been ploughed following a crop of tobacco in the 1942–43 season. Soil: light sandy loam.

TABLE VIII

UNPLOUGHED LAND ON THURBAR

% Weight of Water to Dry Soil

One-inch Layers from Surface	Dates of Samples			
	July 21st	Aug. 21st	Sept. 21st	Oct. 19th
1st	0·39	0·16	0·45	0·21
2nd	0·58	0·52	0·66	0·50
3rd	1·14	0·98	0·90	0·55
4th	1·86	1·68	1·16	0·51
5th	1·61	2·54	1·14	0·52
6th	1·91	2·84	1·07	0·50
Means	1·25	1·45	0·90	0·46

There are some inconsistencies in these results which indicate that the quantity and distribution of water in the soil may vary considerably within a few feet.

(2) **Additional Working to Dry-out Soil.**

Le Roux and Stofberg (1939) have experimented in the Union with additional ploughings in the dry season with a view to drying out the soil more thoroughly, and have reported some benefit in respect to the infestation of the subsequent susceptible crop.

Treatment of this nature, included in the field trials on Thurbar, afforded the opportunity of making some moisture determinations in this connection. The samples were taken month by month with a soil sampler from the top six inches of soil in plots which (1) had been ploughed once only, namely, in May, or (2) were receiving a ploughing each month. A sample was taken from each of six plots in each treatment one week after each of the additional ploughings had been given. The following table shows the mean of six samples in each case:—

TABLE IX

EFFECT OF ADDITIONAL PLOUGHINGS ON MOISTURE CONTENT OF TOP SIX INCHES OF SOIL

Date of Sampling	Treatment	Mean Water %
June 23rd	2 ploughings	2·15
	1 ploughing	2·15
July 23rd	3 ploughings	1·71
	1 ploughing	1·63
Aug. 24th	4 ploughings	1·56
	1 ploughing	1·16
Sept. 22nd	5 ploughings	1·04
	1 ploughing	1·05
Oct. 25th	6 ploughings	0·72
	1 ploughing	0·50

The results of these analyses, therefore, indicate no acceleration of drying from additional working of the soil, that is, taking the top six inches as a whole. The extra working should, of course, tend to conserve the moisture at lower levels.

Acknowledgments.

The writer is again indebted to Miss Kathleen Sturgeon, Division of Plant Pathology, Salisbury, for identification of a number of native plants and weeds, an essential piece of collaboration which has involved a considerable amount of work.

References.

Collins, A. D.—"Eelworm in Tobacco." *R.A.J.*, June, 1938.

Collins, J. C.—Report of Tobacco Research Board for 1937.

Le Roux, J. C., and Stofberg, F. J.—"Control of the Root-Knot Nematode by Cultural Practices." Sci. Bull. No. 188, Dept. of Agriculture, Union of South Africa, 1939.

APPENDIX 1

NATIVE AND WEED HOSTS OF *HETERODERA MARIONI*

Additions and Corrections

The following additions have been made to the list of host plants of the nematode given in last year's Report.

Details of "Class of Host" were given last year, but it may be stated shortly that Classes 1, 2 and 3 represent three diminishing degrees of susceptibility, whilst Class 4 indicates that no infestation has yet been obtained or observed. "N.C" indicates "not classifiable" as yet. "P" indicates pot culture test and "F" field observations.

Family and Species of Plant	Class of Host	Basis	Chief Habitat of Host and Remarks
Gramineae.			
Eragrostis ciliaris, Link ..	3	P	Natural veld and cultivated land; abundant.
Chloris pycnothrix, Trin. ..	2	P	Waste land; natural veld.
Cyperaceae.			
Cyperus amabilis, Vahl. ..	2	P F	*Ex* Class 3 (last year).
Pycreus sulcinux, C.B. Cl. ..	2	P	Cultivated ground.
Commelinaceae.			
Commelina sp. (No. 233) ..	1	F	Common veld plant.
Portulacaceae.			
Portulaca oleracea, L.	1	P	Cultivated and packed soil.
Caryophyllaceae.			
Mollugo cerviana, Seringe ..	2	P	Common weed everywhere
Leguminosae.			
Cassia occidentalis, L.	1	P	Common forest shrub.
Swartzia madagascarensis, Desv.	N.C.	P	Forest tree.
Lotononis sp. (No. 146) ..	3	P F	*Ex* Class 4 (last year).
Crotalaria hyssopifolia, Klotsch.	3	P F	*Ex* class 4 (last year).
Crotalaria buchananii, Bak. f...	3	P F	*Ex* Class 4 (last year).
Crotalaria bongensis, var. shirensis, Bak. f.	3	P	Natural veld and waste land.
Crotalaria anthyllopsis, Welw.	2	P F	Not classified last year.
Crotalaria pisicarpa, Welw. ..	4	P	Natural veld, roads, footpaths.
Crotalaria sp. (No. 130) ..	3	P	Fallow land, pastures.
Crotalaria hislopii, Horbishley	3	P	Natural veld and waste ground.
Crotalaria lachnocarpa, Hochst.	4	P	Waste ground.
Crotalaria rhodesiae, Bak. f. ..	4	P	Natural veld, roads, footpaths.
Crotalaria athroophylla, Verdoorn.	4	P	Forest shrub.

Family and Species of Plant	Class of Host	Basis	Chief Habitat of Host and Remarks
Leguminosae (cont.)			
Indigofera malacostachys, Benth.	1	P	Natural veld.
Indigofera dendroides, Jacq. ..	1	P	Natural veld.
Indigofera antunesiana, Harms.	1	P	(No. 61). Not classified last year.
Indigofera sp. (No. 114/128) ..	3	P F	Not classified last year.
Indigofera hirsuta, L.	1	P F	Not classified last year.
Tephrosia delagoensis (Verdoorn in lit.)	2	P F	(No. 110). Not classified last year.
Tephrosia acaciaefolia, Welw...	3	P	Natural veld and fallow land.
Tephrosia sp. (No. 67) ..	1	P F	Not classified last year.
Smithia Eylesii, Bak. f. ..	1	P	Forest shrub.
Eriosema psoraloides, Don. ..	2	P	Roadsides.
Vigna sp. (No. 123)	1	P F	Not classified last year.
Vigna sp. (No. 105)	1	P F	Not classified last year.
Dolichos trinervatus, Bak. ..	1	P F	Not classified last year.
Euphorbiaceae.			
Acalypha allenii, Hutch. ..	N.C.	F	Low growing veld plant.
Malvaceae.			
Hibiscus ? panduriformis, Burm.	1	P	"Wild Hollyhock." Roadsides.
Sterculiaceae.			
Melhania acuminata, Mast. ..	1	P	Roadsides.
Thymeliaceae.			
Gnidia buchananii, Gilg. ..	4	P	Common veld herb.
Verbenaceae.			
Lantana salvifolia, Jacq. ..	1	P	Forest shrub.
Labiatae.			
Plectranthus laxiflorus, Benth.	1	P F	Not classified last year.
Endostemon obtusifolius, NEBr.	4	P	Natural veld.
Ocimum ? suave, Willd. (No. 76)	4	P	Natural veld and fallow land.
Solanaceae.			
Solanum nigrum, L.	1	P	Garden weed.
Rubiaceae.			
Borreria dibrachiata, K. Schum.	1	F	"Winged Forget-Me-Not." Natural veld.
Cucurbitaceae.			
Cucumis sp. (No. 113)	1	P	Fallow land. Natural veld.
Cucumis metuliferus, E. May..	2	P	"Wild Cucumber." Natural veld. Fallow land.
Compositae.			
Bothriocline (Erlangea) laxa, S. Moore	1	P	*Ex* Class 2 (last year).
Ageratum conyzoides, L. ..	1	P	Prevalent garden weed.
Conyza aegyptiaca, Ait. ..	2	P F	Cultivated and fallow land; natural veld.
Gynura crepidoides, Benth. ..	1	F	Not classified last year.
Senecio sp. (No. 135)	1	P	Natural veld; cultivated and fallow land.

APPENDIX I (*continued*)

The latest botanical advice has necessitated the following corrections or modifications of the names of the plants included in last year's host list. The numbers in brackets refer to the writer's collections, which have been lodged with the Division of Plant Pathology at Salisbury.

Names Given Last Year	Corrections or Modifications
Acacia sp. (No. 48)	Acacia glaucophylla, Steud.
Amarantus graecizans L.	Amarantus thunbergii, Moq. (syn.).
Bidens sp. (No. 160)	Bidens ? bipinnatus, L.
Borreria scabra, S. & T.	Borreria ruelliae (DC), K. Schum.
Borreria stricta, K. Schum.	Borreria diodon, K. Schum.
Clematis simensis, Fres.	Clematis sp. nov. (No. 131).
Cleome monophylla, L.	Var. cordata, Sond, in Linn.
Crotalaria sp. (No. 143)	Crotalaria buchananii, Bak. f.
Erlangea Eylesii, S. Moore	? gen. ? sp. (No. 131).
Gynura cernua, Benth.	Gynura crepidoides, Benth.
Indigofera phyllanthoides, Bak.	Indigofera sp. (No. 70/96).
Indigofera ? monantha, Bak. (No. 125)	Indigofera sp.
Indigofera (No. 115)	Indigofera hirsuta, L.
Indigofera pentaphylla, L.	Indigofera sp. (No. 114/128).
Indigofera sp. (No. 61)	Indigofera prob. antunesiana, Harms.
Oldenlandia thymifolia, Prantl.	Oldenlandia sp. (No. 184).
Polycarpaea corymbosa, Lam.	Var. parviflora.
Solanum ("Bitter Apple")	Solanum panduraeforme, E. Mey.
Tephrosia noctiflora, Boj.	Tephrosia sp. (No. 50/90).
Tephrosia ? flexuosa, Don. (No. 110)	Tephrosia delagoensis, Verdoorn in lit.
Tephrosia capensis, Pers. Ench.	Tephrosia sp. (No. 67).
Vernonia Rogersii, S. Moore	Vernonia Petersii, O. & H.
Vigna lutea, A. Gray	Vigna sp. (No. 123).
Vigna oblongifolia, Rich.	Vigna sp. (No. 105).

APPENDIX II

WEEDS ON DHAL TRIAL CONTROL PLOTS (*see* page 44)—FOUR PLOTS

1942–1943 WET SEASON.

Dominant Weeds on all Plots.—Rhyncalytrum roseum (Natal Red-top Grass), Erigeron canadensis (Horseweed), Tagetes minuta (Mexican Marigold).

Other Weeds.—(1) *All Plots:* Eleusine indica (Rapoko Grass), Eragrostis ciliaris, Cyperus amabilis, Lotononis sp. (No. 146), Indigofera sp. (No. 153), Trichodesma zeylanicum, Helichrysum argyrosphaerum.

(2) *Three Plots:* Laggera alata, Amarantus thunbergii, Polycarpaea corymbosa var. parviflora.

(3) *Two Plots:* Isoberlinia globiflora (Mnondo), root suckers.

(4) *One Plot:* Indigofera hirsuta, Oldenlandia heynei, Gynura crepidoides, Ceratotheca triloba, Leucas martinicensis, Senecio sp. (No. 135), Strychnos spinosa (Kaffir Orange) root sucker, Lantana sp.

1943 DRY SEASON.

Apart from root suckers of forest trees, the only weeds that survived the dry season in these four plots were—

Erigeron canadensis, Amaranthus thunbergii, Ceratotheca triloba and Lantana sp.